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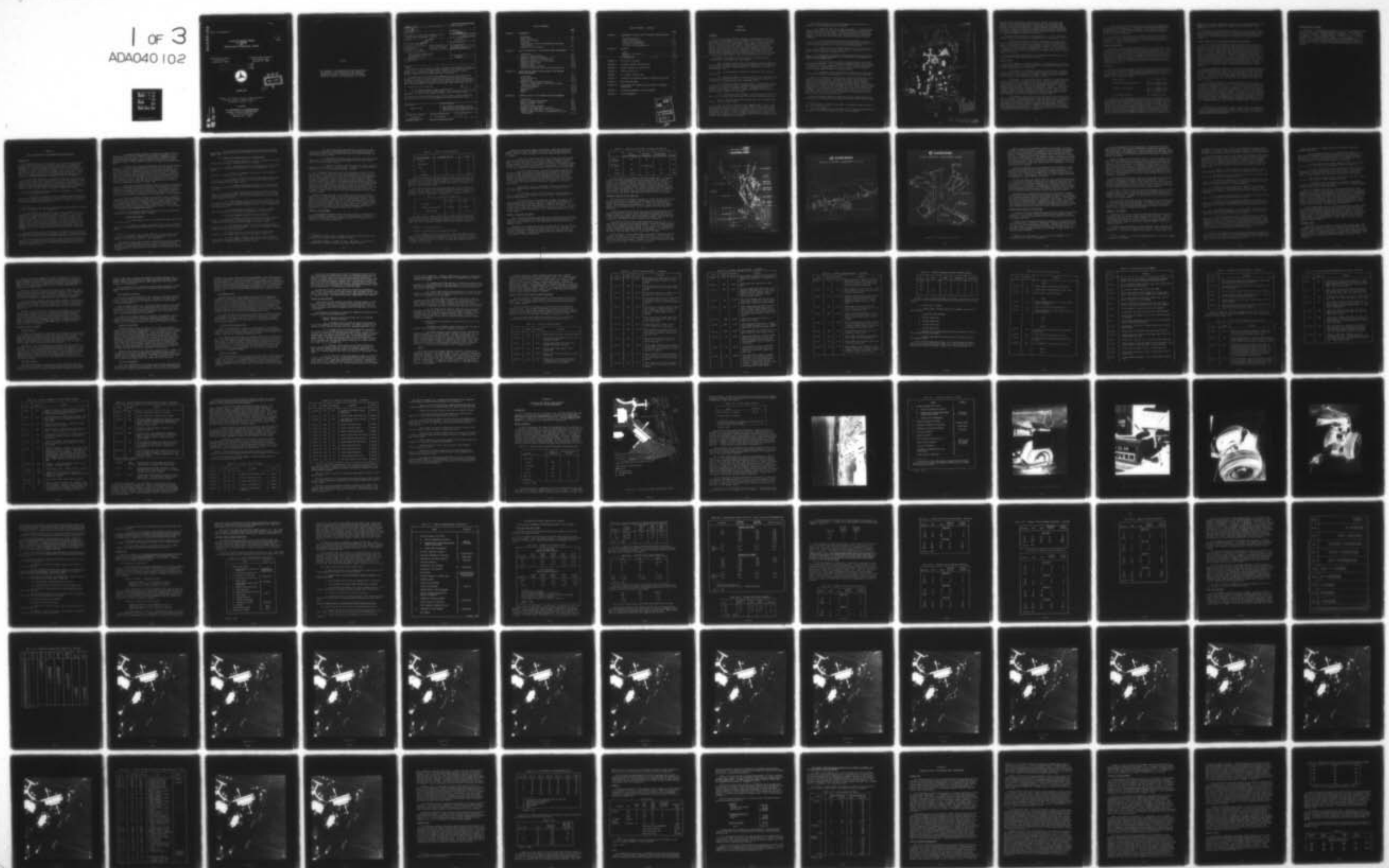

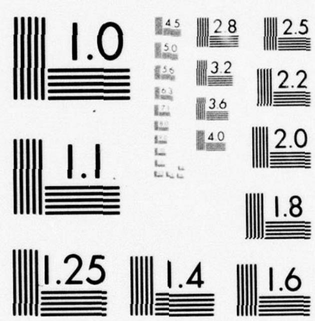
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Report No. FAA-AEQ-77-5

A STUDY OF AIRCRAFT TOWING AS PROPOSED FOR BOSTON–LOGAN INTERNATIONAL AIRPORT

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MARCH 1977

Prepared for

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Environmental Quality
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NOTICE

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16. Abstract

The purpose of this study was to analyze the impact of the proposed revisions to airport rules at Logan International Airport regarding ground movement of aircraft by towing in lieu of taxiing in selected areas. Impacts in the areas of safety, economics, capacity, and environment were major considerations.

The methods used in this study varied depending upon the subject matter under review in the areas of (1) safety--historical data from operating airlines was reviewed, (2) economics--previous economic data regarding the adjacent neighborhoods was evaluated and compared, (3) capacity--actual experience of an involved airline was used, and (4) environment--readings of noise were made under operational conditions.

The results of this study are:

(a) The proposed extended towing is hazardous, and
(b) it raises problems in communications, creates congestion, exposes ground personnel to jet blast, and passengers standing in aisles to possible injury.

Conclusions are that additional studies of these impacts should be made before these proposed revised rules are made mandatory at Logan International Airport.

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SECTION I

INTRODUCTION

BACKGROUND

As part of an overall program to improve the environment in areas adjacent to the airports managed by the Massachusetts Port Authority (Massport), that agency has taken steps from time to time to revise its rules and regulations in such a way as to cause changes in the method of operation of air carriers and others using such airports as Boston's Logan International Airport. On December 16, 1976, Massport's Board adopted a resolution which included changes to Part E of the "Airport Rules and Regulations for Logan International Airport and Lawrence G. Hanscom Field." Part E itself, is entitled "Rules and Regulations Covering Noise Emissions of Aircraft Operated at Logan International Airport," and is the principal focus of this study.

In support of the changes in Part E, Massport cited the following "recitals, facts, and conclusions," among others:

"28. Aircraft taxiing noise is a significantly intrusive annoyance for the airport's neighbors who are located near apron, gate, and hangar areas. In these areas, taxiing aircraft generate noise substantially in excess of normal ambient levels.

"29. Jet and turboprop aircraft make substantial noise emissions when taxiing.

"30. Towing of aircraft, as an alternative to self-propelled taxiing, will lead to a considerable reduction in the noise annoyance experienced in neighborhoods located near apron, gate, and hangar areas.

"31. Towing of aircraft as an alternative to self-propelled taxiing is feasible within certain distance limitations and operational constraints relating to congestion and pavement traction. Equipment required for a partial towing program is available at Logan and equipment for an extensive towing program is commercially available.

"32. A towing program for operating aircraft requiring towing in the apron, gate, and hangar areas designated will not unduly disrupt operations.

"33. A towing program such as proposed will create no <u>undue</u> safety hazards. (Emphasis added by GRA.)

"34. A towing program for aircraft departing and arriving at gate or hangar locations in close proximity to the Jeffries Point section of East Boston should offer substantial noise annoyance relief to residents of that area, which is an area particularly impacted by taxiing noise. The relief to be afforded from towing in those locations is greater than the relief to be afforded from towing at areas of the airport where gates are shielded from the Jeffries Point neighborhood by terminals."

The relevant portions of the revised (December 16, 1976) Part E of Massport's Rules and Regulations are as follows:

"C. Within the daily time periods established[1]....no aircraft operating movement (except for arrivals or departures from South Terminal gates (along the south face of the finger), shall be conducted by self-propulsion westerly of an area near the Airport Fire Station designated by the Airport Manager as the area for towing initiation (inbound) or towing termination (outbound).

"D. An aircraft prohibited from using self-propulsion under this regulation shall not operate any engine used in propulsion while engaged in an aircraft operating movement or an aircraft repositioning movement.

"E. Except in cases of a safety emergency, no tug or tractor shall tow an aircraft unless two-way radio communication is maintained with the Control Tower on appropriate frequencies in use.

"F. Upon request, the Airport Manager may exempt from the restrictions on aircraft operating movements an aircraft which is not equipped with an APU (auxiliary power unit).

"G. The restrictions on aircraft operating movements and aircraft repositioning movements...may be temporarily suspended by the Airport Manager if required to alleviate congestion or delays on the aircraft movement areas or be automatically suspended when snow, ice, or slush on operating pavement surfaces impedes proper operation of towing procedures.

"H. The operator of an aircraft with an inoperative APU may obtain a waiver permit from the Airport Manager for an aircraft operating movement."

Figure I-1 is a general location plan of a portion of Boston-Logan International Airport and environs. In terms of this plan, the Revised Part E makes all aircraft operations to and from the Eastern Airlines Terminal (location 37), to and from certain gates at the South Terminal (location D, which constitutes about one-half of Allegheny Airlines' gates), and all turbine-powered general aviation aircraft operating into or out of the General Aviation Terminal (location 18) subject to the towing rules adopted in December 1976 by Massport. Such aircraft must transition from tow to taxi (or vice versa) in an area south of the fire station (location 39), comprising the inner and outer taxiways at this point (location E).[2]

Prior to Massport's adoption of these revised rules and regulations for Logan Airport, the Federal Aviation Administration (FAA) became concerned about

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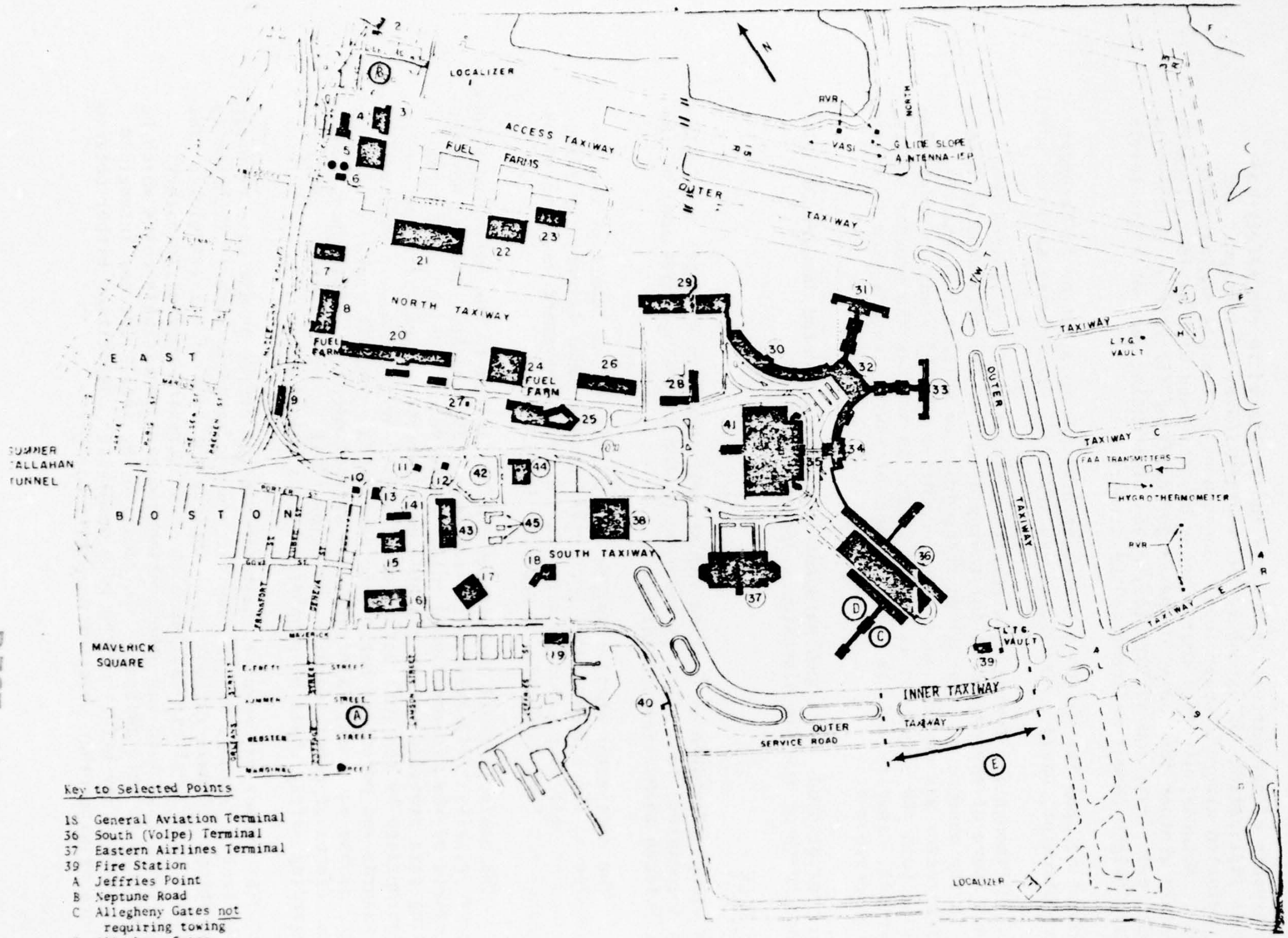
[1]As of January 1, 1978, the regulations are scheduled to apply 24-hours a day. See below, page III-11.

[2]The western boundary of this "transfer zone" is fixed by Massport but not its extent to the east or (around the corner) to the northeast.



Key to Selected Points

18 General Aviation Terminal
36 South (Volpe) Terminal
37 Eastern Airlines Terminal
39 Fire Station
A Jeffries Point
B Neptune Road
C Allegheny Gates not requiring towing
D Allegheny Gates requiring towing
E "Transfer Zone" (inner and outer taxiways)

Figure I-1. General Location Plan, Boston/Logan International Airport.

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several aspects of the matter, especially those related to the safety and operations implications of extensive and routine towing of transport and general aviation aircraft under load. Consequently, the FAA Administrator, Dr. John L. McLucas, directed that a study be performed with maximum dispatch to ascertain whether the towing of passenger-carrying aircraft at Logan would be a safe, practical, and satisfactory means of reducing ambient noise levels in certain neighborhoods adjacent to the airport.

Commenting upon the Massport towing regulations in a letter to Massport Executive Director, David W. Davis, in January 1977, Dr. McLucas said, in part:

"Although the towing of aircraft is acceptable on a limited basis, we are not aware of any precedent for towing on the scale envisioned at Boston Logan. In the absence of established safeguards, we believe that the (FAA) Regional Director was correct in suggesting that a special study be undertaken ...covering both the situation at Boston Logan, as well as the broader safety, environmental, capacity and cost implications of towing, with a view to setting general guidelines."

The present study, produced pursuant to a contract dated January 28, 1977, is one outgrowth of the Administrator's concern.

SCOPE OF WORK

The study undertaken by Unified Industries, Incorporated (UII) and Gellman Research Associates, Inc. (GRA) is governed by the following provisions of the contract between themselves and the FAA:

"The contractor shall complete an analysis of the impact of the proposed revision to the airport rules for Logan International Airport regarding restrictions on self-propulsion of aircraft for ground movement as approved by the Massachusetts Port Authority on December 16, 1976....

"The analysis shall include but not be limited to the following issues in order of priority: (1) safety, (2) economic, (3) capacity, and (4) environmental impacts of the aforementioned rule. Noise reductions shall be determined using data provided by any reliable measurement and analytical source deemed appropriate by the contractor, and approved by the FAA.... Safety shall include hazards and potential hazards to passengers, aircraft crews, ground personnel, ground equipment, aircraft, and airport property. Both short- and long-term effects of complying with the rules shall be investigated. Conclusions regarding safety shall be supported by historical data.

"The impact on capacity shall include the effect on air carrier operations, air traffic volume, FAA procedures, and the economic effect of change in these operations. Considerations shall include the cost of air traveler's time, fuel savings, additional air carrier cost, and increased capital investment. The contractor may include any other reasonable and quantifiable costs which he deems applicable to this analysis. In addition, he shall list any intangible costs and estimate any effect of the rule on airline competition either between air carriers or with other modes of competition.

"The contractor shall limit his analysis to the most probable means of compliance with the rule, (i.e., towing by currently owned or commercially available tractors or reductions in operations). Consideration will not be given to alternative means of propulsion which require extensive equipment design or airport construction."

In subsequent clarification of the Statement of Work, the FAA directed the contractors to consider as beyond the scope of the study any equipment acquisition or capital investment program at Logan Airport which would require greater than six months to be completed.

PERIOD FOR PERFORMANCE

Under terms of the agreement, the contractors were to provide the FAA with a "preliminary draft of the final report" on Friday, February 28, 1977. This deadline was met, even though the draft was incomplete partially because it had not been possible to obtain the last increment of noise and towing operational data, since one additional towing test required at Logan had been postponed due to conditions beyond the control of either the FAA or the contractors. As a result, delivery date for the final report on the project, which was originally Friday, March 11, 1977, was subsequently advanced to Friday, March 18, 1977, which date has been met.

STUDY TEAM

This report has been prepared by a study team selected by UII and the FAA and consisting primarily of staff personnel and consultants to GRA. While overall responsibility for the program rested with James Hillman (UII) and Dr. A. J. Gellman (GRA), the principal efforts with respect to the various issues being addressed were assigned as follows:

Safety Analysis	Mr. H. P. Schmidt (GRA)
Operations and Capacity Analysis	Dr. E. E. Bomberger (GRA) Mr. H. P. Schmidt (GRA)
Economic Issues Analysis	Dr. A. J. Gellman (GRA) Dr. E. E. Bomberger (GRA) Mr. W. Scheirer (UII)
Environmental Analysis	Mr. Joe McKnight (GRA)

In addition to the study team from UII and GRA, it is important to note that approximately midway through the program the FAA made arrangements for Massport to provide a consultant of its own to join the study team. Massport designated Mr. John Forsyth, an independent consultant to Massport with substantial experience analyzing aircraft towing scenarios. Mr. Forsyth met on one occasion with the full UII/GRA study team and subsequently participated in towing and noise emissions tests carried out at Logan Airport in early March. Unfortunately, due presumably to the lack of time or other resources, Mr. Forsyth did not make a further contribution to the overall effort, even

though certain specific issues were raised for his consideration shortly after he had been retained by Massport in conjunction with this project. (See appendix A.)

FAA personnel provided substantial assistance to the study team in the form of data and information not readily obtainable from other sources. While FAA personnel did not participate in the analysis and deliberations leading to this final report, their contribution in support of the study team was invaluable.

GENERAL NATURE OF DATA AND INFORMATION UNDERLYING THE ANALYSIS

Much of the data and information required to perform a thorough-going analysis of certain aspects of the Massport towing proposals is either obscure or nonexistent. This became especially apparent as the study team came to grips with a number of the safety issues which, after all, had been given priority in the work program and in the allocation of resources by the study team. For example, it was early determined and repeatedly brought to the study team's attention that there is very little quantitative material related to the strength requirements and the stresses experienced by aircraft nose landing gears when subjected to forward-direction towing under load. Neither the manufacturers of transport aircraft nor of general aviation aircraft were able to provide "hard" data in this area, although virtually all of them suggested that such material could be developed, given sufficient time and resources.

Substantial quantitative material and much useful information was obtained or developed in the course of the study. In this connection, especially valuable was the cooperation of Eastern Airlines, Allegheny Airlines, Van Dusen Air, Inc., Massport, various airframe manufacturers, and aviation trade associations. Indeed, with only a few exceptions, all parties whose cooperation was sought in conjunction with supplying data and information performed in a timely fashion.[3]

It is especially important to recognize that the science (or art) of measuring and evaluating noise is in its relative infancy, and literature on the subject, though already voluminous, is not very well developed from either the practical, analytical, or technique standpoints. Even more of a problem is the fact that there is no general agreement as to how noise and economic impacts relate one to another and, indeed, in some areas, no viable techniques to accomplish this have yet been suggested. Consequently, the study team was faced with the necessity to draw on the literature and experiences available to the present time to make judgments about the extent and characters of the noise impacts and their possible economic consequences where the most "sensitive" neighborhood adjacent to the airport, Jeffries Point, is concerned.

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[3]The principal exception must be noted: Butler Aviation at Logan Airport is one of two fixed-based operations (FBO's) on the airport. While Butler repeatedly pledged cooperation in supplying data on GA activity at Logan, the material promised was not delivered.

ORGANIZATION OF THE REPORT

This report is organized quite conventionally. That is, separate sections cover the several issues addressed by the work program: safety, operations and capacity, economics, and environmental. In addition, the study team has produced a series of "findings" which it believes to be wholly supported by either direct or circumstantial evidence. It is anticipated that these findings will be employed by FAA in developing and promulgating policies related to the towing of loaded transport and general aviation (GA) aircraft in support of noise amelioration at Boston-Logan International Airport and elsewhere.

SECTION II

SAFETY IMPLICATIONS OF THE MASSPORT TOWING REQUIREMENTS

INTRODUCTION

The excellent safety record enjoyed by U.S. airlines has been achieved through painstaking attention to technical, human factor, and operational considerations. Analysis has preceded the adoption of new technology or procedures. Caution has governed the industry's exploration of new frontiers since Murphy's Law ("if anything can go wrong, it will") was discovered; in the aviation industry, lack of caution has had tragic consequences. In general, the FAA, when engaged in its critical function of promoting aviation safety, has resolved both conflicts and doubts on the side of caution.

In reviewing the documentation available to support the proposed Massport regulation on towing, little is found which answers the many important safety issues raised by technical or operational requirements. Although there is no doubt that many of the present questions can be satisfactorily answered, it is nonetheless important that answers be developed before initiating widespread towing of "heavy" aircraft rather than after such towing has started.

Caution in implementing the proposed towing requirements is recommended in view of certain important factors:

° This review of towing in general has indicated that towing experience by the airlines has not been good. The substantial number of towing accidents (not associated with the push-back operation), suggests that towing is a more hazardous operation than taxiing.[1]

---

[1]The following is from a letter by the Manager-Contracts/Budgets, Allegheny Airlines, dated January 11, 1977 (appendix B).

"At approximately 2245 on August 21, 1976, Aircraft N985VJ (DC-9) was being towed to Allegheny's hangar by maintenance personnel. As the aircraft approached the hangar ramp, the wheels on Huff Tractor #38 locked up and skidded approximately 3 feet on dry pavement. The sudden stoppage of the tractor resulted in the failure of the shear bolts in towbar and excessive rearward torque loading of the nose gear when the towbar contracted to its minimum length. This action caused the failure of the nose gear drag strut attached, structure drag link, excessive damage to the station 110 pressure bulkhead and excessive structure damage to the frame below the station 110 bulkhead.

"The aircraft came to rest with the nose gear upper housing cantered [sic] aft approximately 30° against the 110 bulkhead structure, restraining further nose down attitude and preventing the radome from coming to rest on the tractor.

"The labor and material cost for this incident will total approximately $200,000. This incident portrays the potential hazard that exists during a towing operation where lack of coordinated commands between the cockpit and the tractor operator exist."

° The present Massport regulation contemplates aircraft towing of a character and on a scale not conducted at any airport; consequently, it may well involve exposures rarely, if ever, experienced in commercial aviation given that Massport proposes to require routine towing of both air carrier and general aviation turbine-powered aircraft while loaded with passengers and fuel.

° The nose gears of transport and general aviation aircraft were not designed for extensive towing under load as Massport seeks to require. The nose gear's ability to withstand the stresses has not been determined and, in fact, there remains a substantial question concerning the fatigue stresses that may be imposed and the consequent potential for failure. A preliminary analysis of increased loads/decreased fatigue life by two manufacturers suggests the possibility of a 95% reduction in fatigue life because of a substantial increase in stress.[2] Although this must be recognized as representing only a preliminary guesstimate, the order of magnitude change from current procedures underscores the need for further study.

° The proposed operation jeopardizes one of the underlying principles which has traditionally (and legally) governed aircraft operations: The pilot (captain) has absolute control over his aircraft. By inevitably placing the tug driver in de facto control of the towing process, the captain's authority will, at best, be diluted and there are likely to be instances in which the tug driver and the pilot act independently to the detriment of a safe operation.

It is clearly of importance that all safety-related issues be explored in depth prior to initiating the full towing called for by the Massport proposal. As the FAA normally requires a proponent (which is generally either an airline or the manufacturer, but in this instance, Massport) to substantiate a proposed change through analysis of its effect, particularly on safety, those same issues must first be addressed in this Boston instance. This requirement is in accordance with accepted FAA principles.[3]

This analysis of proposed towing at Boston finds reservations regarding safety levels in three separate areas as follows:

a. General Reservations.

(1) Towing appears to be a more hazardous movement than taxiing by a factor of 19:1.

(2) There is a question concerning the nose gear's structural ability to withstand additional fatigue stresses. Fatigue life may be reduced by 95%.

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[2]Ref: Letter from M. Stone, Douglas Aircraft to N. Krull, FAA, dated Feb. 23, 1977 (appendix C); and letter from H.W. Withington, Boeing, to Colonel C. R. Foster, FAA, February 7, 1977 (appendix D).

[3]On seemingly minor items, the FAA has required analysis before adoption. For example, before permitting an airline to place a "No Smoking" sign on seatbacks, an engineering justification was needed to confirm such matters as fire-proof qualities, placard design, the potential for sharp corners cutting occupants, etc.

(3) The concept of placing control over the aircraft in doubt, with divided responsibility between the captain and tug driver, may erode the safety level.

b. Reservations With Regard to Early Implementation.

(1) The structural integrity of the nose gear must be determined through analysis prior to implementation of this program.

(2) Rules and procedures must be developed by both the airlines and the control agencies (FAA and Massport) before implementation in such areas as:

(a) Who is in command of the aircraft, and through what means does he communicate with others?

(b) Who is responsible for monitoring weather changes and its impact on flight operations? That is, neither the FAA nor Massport can take responsibility over flight dispatch.

(c) Further consideration should be given to regulations concerning towing an aircraft which does not have an operative auxiliary power unit (APU).

(d) A more thorough analysis by the industry concerning the need for obtaining "thermal stability" within the engine prior to takeoff. Under present operations this is not a critical problem at any airport; it may be more important at Boston.

(3) A more thorough study of the tug vehicles themselves. Are they capable of providing sustained long-range, high-speed, heavyweight towing; are their brakes capable of standing up under this use; is their communication gear appropriate; etc.?

(4) A more thorough consideration of tug driver personnel, their training, qualifications, physical requirements, licensing, etc.

c. Reservations Regarding the Specific Boston Proposal.

(1) The regulations appear to place the tug driver in control of the aircraft movement. This subject requires substantial thought and consideration before resolving the many human factor safety issues.

(2) The regulations appear to place certain flight dispatch control decisions in the hands of Massport. This must be thoroughly considered before final regulations are adopted.

(3) Dead spots exist on the ramp, making communications between the tower and the typical tug either uncertain or impossible.

(4) The mixing of aircraft (some under tug power and others being taxied) with large numbers of ground vehicles will cause congestion and the potential for additional hazards for all vehicles.

(5) Since some engines are difficult or impossible to start with strong crosswind or tailwind conditions, the limited area assigned for starting may restrict certain aircraft which desire to start facing into the wind for operational reasons.[4]

(6) The potential ability to take off within very short periods after start raises questions of engine performance and reliability before thermal stability has been achieved.

(7) There is a question concerning the intent of the regulations concerning aircraft without an operating APU. In general, it appears that an operating APU is vital to towing fully-loaded aircraft.

It is recognized that airlines do tow aircraft under certain conditions, and that towing "has its place" in the ground movement of aircraft. In general, towing is associated with a maintenance function and is performed during relatively quiet hours; there is little stress on the personnel to minimize tow time for competitive reasons; there may be unique reasons for towing in specific instances (for example, not having maintenance personnel checked-out in taxiing the aircraft places a requirement on the airline to tow the aircraft). Finally, in very congested areas, towing is regarded as a "safe" operation with ground personnel serving as wing walkers, the aircraft moved at very slow (walking) speeds, and during the push-back operation no real control over personnel is imposed by the control tower which would disturb the crew responsibility doctrine.

On the following pages the various elements of concern are discussed in greater detail. They represent a variety of technical, operational, and personnel issues which are interwoven into the ground movement subject. These subjects are discussed in the belief they require much more study individually and collectively--the industry typically will utilize a "fault tree"[5] analysis process to evaluate potential safety considerations--before reasonable answers can be obtained to the question "can the proposed Massport regulation be implemented in a safe and reasonable manner; and if so, how?"

TOWING VS. TAXI ACCIDENTS

A direct comparison between towing and taxiing safety is impossible since directly comparable situations do not exist within the industry. However, a study of all towing and taxiing accidents experienced by one major U.S. airline leads to the following comparison:

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[4]Manufacturers and airlines recommend turning an aircraft into the wind when difficulty is experienced in starting an engine.

[5]Fault-tree analysis is a "what if" game. One failure or malfunction is traced through all affected systems to determine failure impact.

Table II-1. Taxi vs. Towing Accidents[6]

Cause-Personnel	Push-Back and Tow	Taxi
Flight	4	16
Maintenance	42	9
Other	2	4
Total	48	29
Percent	62%	38%

The above data indicate that maintenance personnel are responsible for the majority of all ground operations accidents: maintenance personnel were responsible for 66% of all accidents, of which 55% occurred during push-back and towing; flight personnel were responsible for 26% of all accidents, of which 21% occurred during taxiing.

The comparison appears more unfavorable when one considers the exposure involved. For the same airline, data were obtained concerning exposure to towing to/from the hangar as well as the exposure to taxiing accidents. From that data a relative comparison of accident rates is possible, as follows:

Table II-2. Accident Rate Comparison[7]

	Tow	Taxi
Accidents	28	29
Exposure (operations)[7]	109,000	2,166,000
Rate/100,000	25.7	1.34

The above analysis suggests that towing is approximately 19 times more dangerous than taxiing. This relative safety level is considered important when considering the proposed Massport regulations and should, at the minimum, cause substantial restraint in adopting such aircraft movement techniques.[8]

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[6] Airline C--3 years experience.

[7] Airline C--Data (for taxi) and estimate (for tow).

[8] In data submitted to the FAA from the ATA, one of their members stated that his data indicated "towing and push-outs are liable to cause a higher number of ground accidents by a factor of 3.7 than taxi operations." Attention is drawn to the fact that the 3.7 refers to towing plus pushout, whereas the 19 refers only to towing.

Although the above data suggest that taxiing is safer than towing under present conditions, there are reasons to believe that the proposed towing at Boston will have a greater frequency of accidents than present towing does. For example:

° Towing under present conditions tends to take place during nighttime periods when the aircraft is moved from a gate to the hangar for maintenance. At such times there is little ramp congestion of either aircraft or ground equipment, which reduces the exposure to collision with ground equipment; and there is little urgency to complete the towing process in a minimum amount of time, which reduces the amount of pressure placed on the airline personnel.

Each of the above factors--congestion from ground equipment and possible pressure on personnel--is important and contributes to many ground accidents. Under the proposed Massport regulations there would be extensive congestion on the ramp from both ground equipment and aircraft, and there would be substantial pressure placed on both ground and flight personnel to complete the towing in the minimum amount of time in order to retain competitive schedules with other airlines which are not subjected to the towing requirements.

Both of these issues are important to safety considerations and must receive appropriate consideration if towing is to remain as safe as taxiing has been.

° Present towing normally does not take place with passengers onboard, flight crews in the cockpit, or full fuel loads. These issues are discussed further below.

° Towing is presently performed with a mechanic driving the tug and another mechanic in the cockpit. The fact that both these individuals have the same background and experience suggests a different reaction (by the person in the cockpit) than would apply were a pilot in the cockpit. A mechanic in the cockpit is not likely to overrule the tug driver; a pilot in the cockpit may well overrule the tug driver. This is also discussed in later sections of this report.

TOWING VS. PUSH-BACK ACCIDENTS

Since the proposed Massport regulations will not change the basic need for push-back, it will primarily affect the additional towing requirement from the ramp area to the transfer point. This requirement will be felt initially by Eastern Airlines.

Through the Air Transport Association, accident data for 15 airlines have been received by this study team (see pages II-20 to II-33). That data, which has also been given to the FAA, includes accidents from both push-back and towing to the hangar. Following are certain statistics comparing the number of accidents in towing and push-back:

Table II-3. Comparison of Accidents in Towing and Push-Back

	Towing (to/from hangar)	Push-Back (from gate)	During Hookup and Disconnect	Total
Damage to Aircraft	102	44	-	146
Injury to Personnel	43	3 (2 fatalities)	20	66
Total	145	47	20	212
Percent	68%	22%	10%	100%

In each of the towing accidents (to/from the hangar) there is a mechanic in the cockpit while a mechanic on the tug controls both the tug and the aircraft. In the proposed Massport regulation there would be a pilot in the cockpit while a mechanic on the tug would control both tug and aircraft. Having a pilot in the cockpit while a mechanic on the tug controls both vehicles may prove less safe than current procedures because of divided responsibility and uncertain authority. This issue is discussed later as "command of the aircraft." But whatever the chain of command/responsibility, towing is seen to involve substantial risks compared to either taxiing or push back.

STRUCTURAL INTEGRITY OF THE NOSE GEAR

The nose gear of an aircraft is designed to satisfy its particular purpose and has been designed in accordance with the normal loads imposed upon it. Neither the gear nor any other component is designed to withstand loads or stresses which exceed design specifications. Design specs are based upon an analysis of "the intended purpose" of the component in an actual operating environment.

The design specifications for the nose gear include consideration of the loads associated with taxiing, takeoff and landing, push-back (with a fully loaded aircraft) on a regular basis, and towing to the maintenance hangar on a relatively infrequent basis (with an unloaded aircraft). The gear has been designed and certified by the FAA to satisfy these requirements.

Based upon discussions with aircraft manufacturers and airlines, it is clear that the nose gear has not been designed to satisfy the loads associated with extensive towing of a fully loaded aircraft. In fact, the manufacturers do not even know what the loads would be in such towing. This requirement has not been included in engineering testing, and therefore it is impossible to speculate on the nose gear's ability to withstand such loads.

The nose gear is a complicated assembly which pivots during lowering and raising. A schematic of the gear is shown in figure II-1. Critical areas tend to be the drag braces (both upper and lower), the side brace system, and in internal shock strut elements. Schematics of a towbar and shear pin connection are shown in figures II-2 and II-3, respectively.

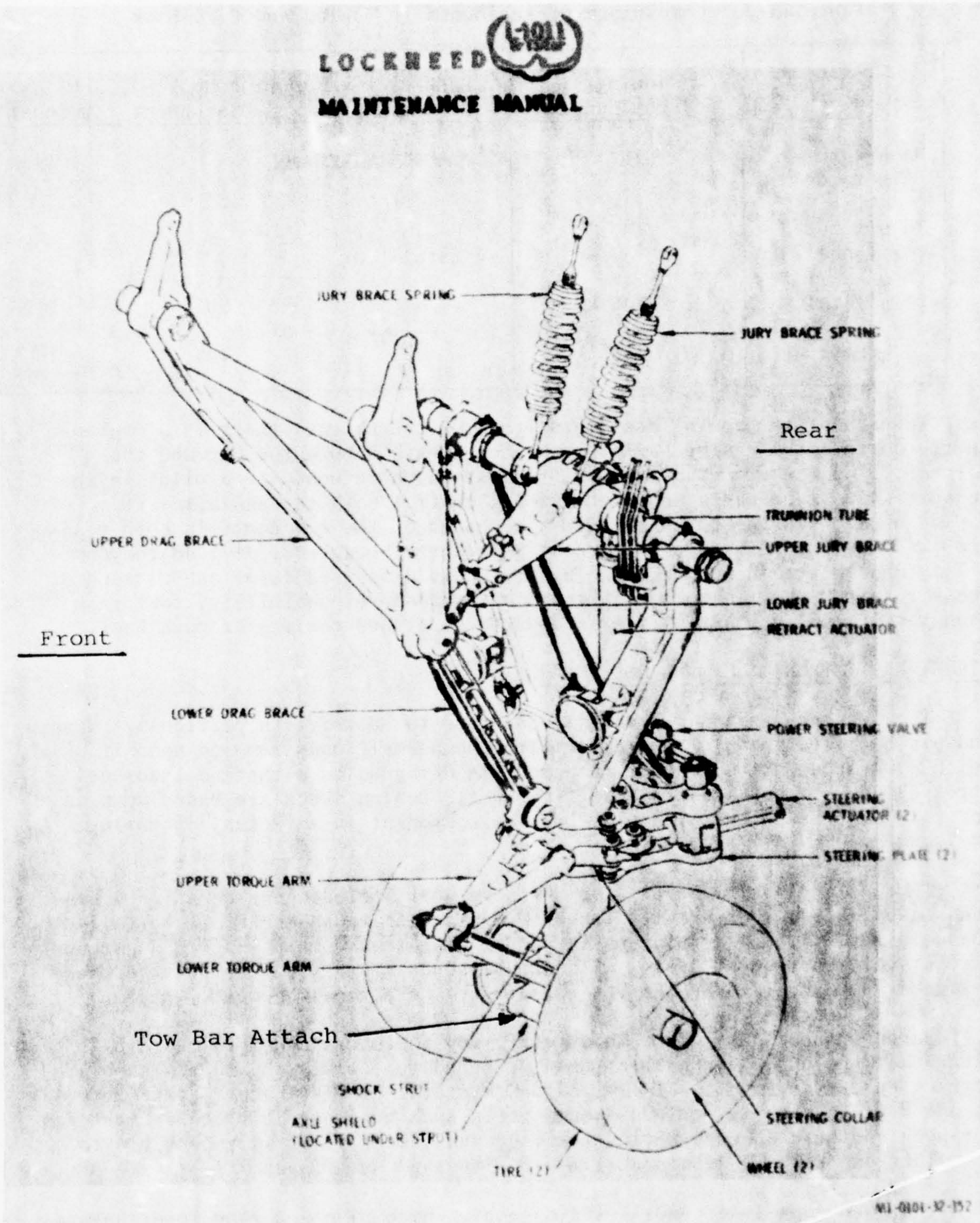

Figure II-1. Nose Landing Gear Subassemblies

EASTERN

GROUND EQUIPMENT MAINTENANCE MANUAL

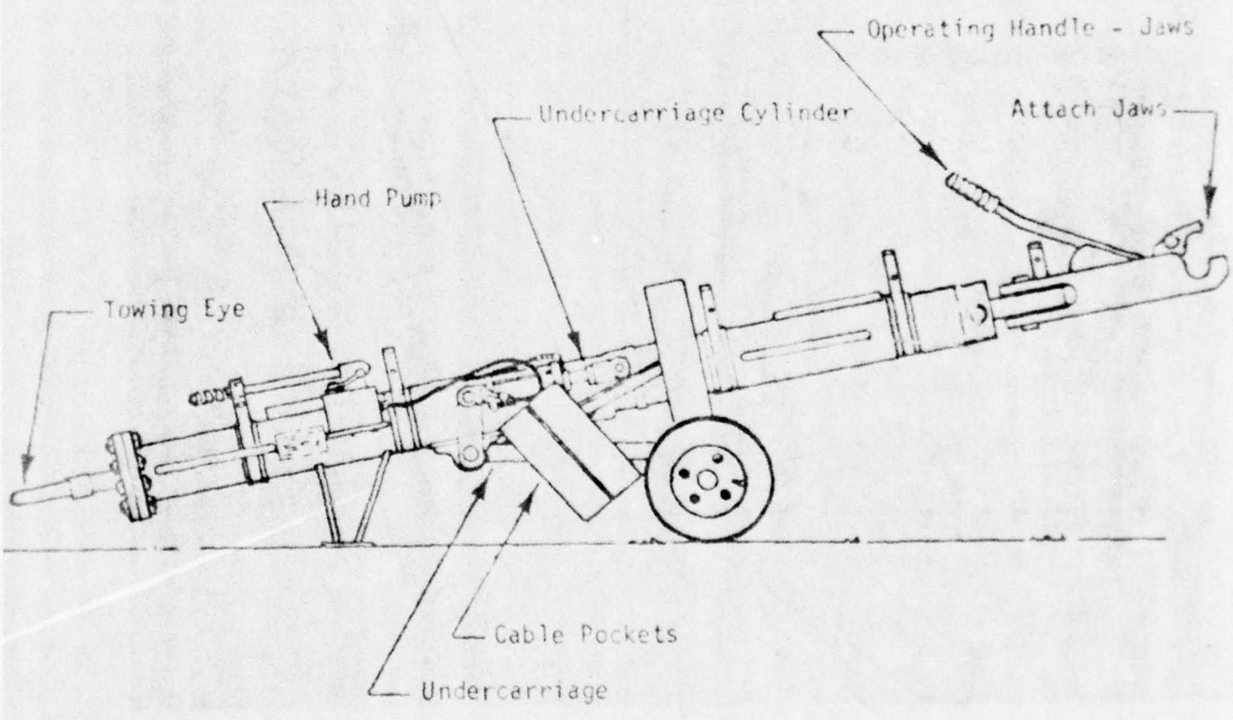

Figure II-2. Lockheed L-1011 Towbar

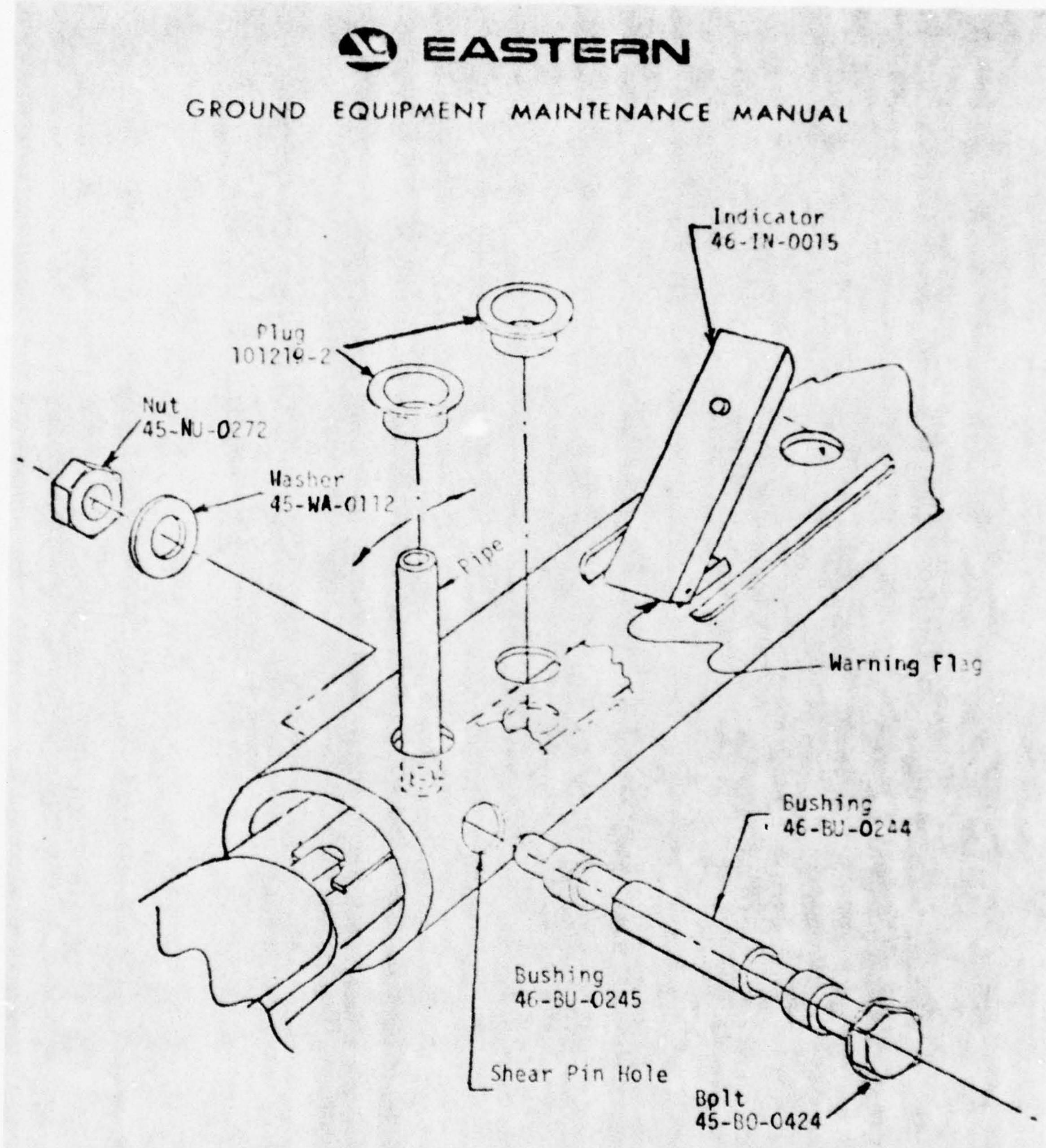

Figure II-3. Axial Shear Pin Replacement

Before answers can be developed to confirm the nose gear's structural integrity, it would be necessary to conduct real-world testing and evaluation. Towing of actual aircraft on the Boston ramp, with typical airline mechanics using an instrumented towbar, would define the loads imposed by the towing operation. It should be pointed out, however, that until and unless such towing has been demonstrated to be safe from the standpoint of aircraft structural integrity, such tests should be conducted with aircraft not being used in routine passenger service. This means that the aircraft employed for such tests must not be placed in normal fleet service until its airworthiness is assured following the test program.

Particularly important in the test program will be the number of starts and stops which impose the "fully reversed cycle" loads on the gear. These reverse cycle loads are critical with respect to fatigue stresses since relatively small increases to the number of cycles causes substantial change to fatigue stress. For example, a 10% increase in cycles (loads) doubles the fatigue damage and reduces fatigue life by 50%.

On the Boston ramp, with several stop/start and acceleration/deceleration cycles between the gate and the firehouse, it is possible that there would be a 20 times increase in fatigue damage and a 95% reduction in fatigue life. Boeing states, "If aircraft were subjected to an increased amount of towing and/or increased towing speeds, we would expect an increase in both the amount of handling damage to the nose gear at the towbar attach points and the incidence of fatigue cracking in nose gear and nose gear attach structure."[9]

The magnitude of increased fatigue stresses is potentially of serious concern and may require substantial action, either in the form of a redesign or a modified maintenance inspection and overhaul procedure. Although revised maintenance/overhaul procedures may be adopted by the industry, it is doubtful that a retrofit program could be accomplished, at least in the short term, should that fix become necessary. Whatever the nature of the technical solution, consideration will have to be given to optimum economic solutions recognizing different exposure by different airlines, individual aircraft, etc.

MECHANICAL RELIABILITY OF THE NOSE GEAR

In addition to fatigue damage from towing, which may affect the structural integrity of the nose gear, excessive towing loads can also affect system reliability. These day-to-day operations can increase operating and maintenance problems and costs.

Probably the most frequent mechanical irregularity to be anticipated concerns the shear pin in the towbar. These have a history of premature failure causing an aircraft to be temporarily disabled. Although such failure will not always cause an accident, inadvertant failure of the shear pin must cause additional ramp congestion and delay to all subsequent aircraft behind the aircraft directly affected.

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[9]Boing letter dated February 7, 1977, from H.W. Withington, V.P. to Colonel Charles R. Foster, FAA (appendix D).

Not to be discounted are the large number of problems which can arise when a complicated system such as the nose gear is frequently subjected to additional cycles. The combination of loads associated with additional starts, stops, and turns; ramp irregularities; driver techniques (not providing uniform pull on the towbar); and ramp condition variations can magnify the mechanical reliability problem.

During any towing or taxi operation, there is a vertical movement of the nose landing gear shock strut as a result of rough taxiways, starting, stopping, etc. The nose landing gear deflections are greater during towing than during any other load spectrum. Increasing the towing distance--such as to and from the end of the runway--will increase the number of vertical cycles of movement while the strut is highly loaded and deflected in the horizontal direction. Except for towing of an unloaded aircraft to the hangar, the nose gear is designed to withstand deflection aft during normal ground and flight operations. The forward pull of the towbar during prolonged towing may have unforeseen consequences.[10]

As a result of this additional stress, various portions of the nose gear system will deteriorate more rapidly than under normal use. There will probably be a deformation of seals and the piston, which will result in fluid loss and increased damage to chrome. Loss of fluid will reduce or eliminate the shock absorption qualities of the nose gear strut, thus transmitting loads which may exceed design loads directly to the aircraft structure.

Also, loss of fluid or air may not allow the nose gear piston to completely extend on takeoff. If this occurs, the nose wheel centering cams will not engage and the nose gear may retract with the wheels turned, or the wheels may retract and then turn. In either case, the gear may jam in the "up" position forcing a nose-gear-up landing.

The greater nose gear loads can place additional stress on the gear which will accelerate other mechanical problems. For example, torque links, which are vital to the nose gear steering system, are a frequent source of mechanical problems. Excessive towing with full loads may increase the susceptibility of this system to malfunction or failure.

COMMAND OF THE AIRCRAFT

The history of aircraft accidents has shown that human factors tend to be more responsible for aircraft accidents than mechanical elements. However, although the human may be the system's weakness, it is also aviation's greatest strength since commercial pilots have always been highly regarded for their professional capability and the use of mature judgment in resolving complex situations.

One basic principle governing aircraft operations is the authority given to the captain over all events affecting his aircraft. Part 121.533 of the FAR states "... Each pilot in command of an aircraft is, during flight time,

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[10]Ref: Professer R. S. Shevell, Stanford University, letter to A. Gellman 3 February 1977 (appendix E).

in command of the aircraft and crew and is responsible for the safety of the passengers, crew members, cargo, and airplane." During the preflight briefing the captain signs a dispatch release form which acknowledges this responsibility.

The proposed towing regulation will, however, place the tug driver in *de facto* control over the aircraft, contrary to all other principles of authority governing aircraft operations with passengers on board. (It is recognized that mechanics are responsible for control of the tug and of the aircraft during towing to a hangar for maintenance, but this is without passengers on board.) This division of authority may lead to faulty decisions being made under stress:

° The captain will not relinquish his absolute authority over any operations which appear to him to involve his responsibility for safety.

° The tug driver may not recognize (or be told in time of) matters which affect aircraft and/or passenger safety.

° The three-way communications link between the control tower, the cockpit (the captain), and the tug driver is complicated and offers the real potential for significant delay or misunderstanding.[11]

° Communications with the tug may be impeded by either the high noise level in the tug or a poor communications set (many tugs have poor radios which are difficult to maintain to the high levels required of flight equipment).

° The captain and the tug driver have different perspectives of the ramp situation, and hence may make different decisions.

° There may be an on-board emergency unknown to the tug driver. Any delay in achieving immediate communication with the tug may force unilateral action by the captain. Extended towing increases the exposure time to this risk.

° The tug driver's exposure to adverse weather conditions or the jet exhaust from aircraft immediately in front of him may cause him to take unexpected actions to relieve his personal discomfort.

° Finally, the question of who is in control of the aircraft is dangerously vague. There may be instances when both the tug driver and the captain act in opposite directions, each believing his action proper. With the captain exercising his control only through the brakes, the towbar may be sheared, which will temporarily disable the aircraft and may damage portions of the nose gear. This question of control would have to be specifically covered in flight crew operations and maintenance manuals.

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[11]Even two-way communication presents problems between the captain and the tug driver. For example, in the ATA data there were three accidents (1.5% of the total) resulting from improper use of the brakes resulting from inadequate coordination between the tug and the cockpit.

This split authority in controlling the aircraft raises a number of potential conflicts:

° When an emergency arises in the captain's mind (either as a result of radio communication which the tug driver does not interpret in the same manner, or resulting from his better visual view of ground conflicts), he will probably use the only method of control at his disposal--the brakes--to stop the aircraft. This can cause damage to the nose gear.

° If the emergency is an on-board emergency, stopping the aircraft may also disable the aircraft with the emergency condition remaining.

° If the aircraft does not have an operating APU and is relying on the tug for all power, stopping the aircraft may also tear out the power line rendering the aircraft not only disabled, but also without a normal power source. Emergency battery power may not last for more than a few minutes.

° Any emergency stopping by the captain may be sufficiently hard as to cause personal injury to anyone standing in the aisle.

° An emergency stop by the captain, in addition to damaging the nose gear and tearing out any power cables, will also tear out hard interphone connections between the cockpit and the tug.

The above are merely illustrations of problems which may arise when authority over controlling the aircraft is not firmly established. Massport's regulations appear to assign responsibility to the tug driver. Although additional revised procedures may be adopted by the airline to put responsibility in the tug driver's hands, the captain will surely initiate action if he considers a situation an emergency. If, on the other hand, procedures place control in the captain's hands, then total reliance is placed upon a communications link with the tug. In either case, there may be potential problems which can affect the safety of both personnel and aircraft.

The decision-making process will be further complicated by extreme congestion of both ground vehicles and aircraft, and the fact that some aircraft will be taxiing while other aircraft will be towed. The mix of vehicles moving at varying speeds, each under the stress of a competitive environment between airlines, will add complication and the potential for a reduction in safety margins. The alternative may be for the tower to impose stringent ground movement restrictions which may increase delays by reducing airport runway and taxiway capacity.

PASSENGER SAFETY

Present aircraft towing normally does not involve aircraft loaded with passengers; hence, there is little or no passenger safety involvement. The initial aircraft push-back from the gate is of such short duration, and occurs at the beginning of a flight, that there is little exposure from people standing in the aisle. The Massport regulation presents a new environment in which greater exposure to passenger safety from standing in the aisle may be envisioned.

First, it will involve towing "in" as well as towing "out." The tow-in may be unusually critical: When the aircraft is stopped near the transfer point, passengers will normally think that "they have arrived," and many will arise and stand in the aisle. Experience has shown that once passengers have arisen, it is extremely difficult for the crew to obtain compliance with "return to your seats" orders.

Second, the relatively long (10 to 15 minutes) taxi-in delay will cause impatience among passengers, encouraging them to stand up, collect baggage and coats, and try to be the first to leave to make connections, etc. This is a current problem when taxi-in times are only 3 to 5 minutes at many stations; certainly the problem may be aggravated under these proposed regulations.

Finally, the tow-in procedure will very likely be rough at certain times, resulting either from poor driver techniques, ramp unevenness, or the captain's application of the brakes. A desire to minimize taxi time (for competitive reasons) by towing at the fastest speed consistent with safety will accentuate the problem.

While this issue may not result in death or major injury, it may cause minor injuries stemming from falls. Airline records indicate that perhaps five passenger injuries per year are attributed to present push-backs or taxiing; certainly the exposure under this regulation would be far greater, and it is possible that Massport would be involved in litigation since the injury was caused pursuant to Massport regulations. Moreover, the FAA itself might conceivably be sued since it presumably failed to enjoin an unsafe practice within its jurisdiction.

ADDITIONAL ITEMS OF CONCERN

Weather Exposure:

The additional ground delay caused by the taxi procedure for takeoff will permit additional accumulation of snow, frost, and ice on the aircraft. Under heavy snow conditions, applications of glycol may last only 10 minutes, barely permitting an aircraft to takeoff if it encounters no delay before takeoff. With another 10 to 15 minutes added to the taxi-out time, applications of glycol prior to being towed may be ineffective.

Although it is easy to require pilots to return to the gate should they find snow, frost, or ice again accumulating, obtaining full compliance is more difficult. It may be impossible for the pilots alone, particularly in swept-wing aircraft, to assess accurately snow, frost, or ice accumulation; they may feel the airport is about to close due to adverse weather and hence are under additional pressure to take off now rather than return for another glycol application, since returning may only cause additional delay without solving the inherent problem.

Crosswind Exposure:

The wide-body aircraft are susceptible to strong crosswinds when under tow, and it may be difficult for the tug to maintain control over the aircraft. Reference to the history of accidents (shown earlier) indicates one aircraft

towing accident when a wide-body was damaged in a strong crosswind. The Massport regulation may greatly add to this problem since wide-body aircraft will be exposed to high crosswinds for longer periods of time during long-distance, slow-speed towing.

Studies conducted by one airline have indicated that a wide-body aircraft becomes unmanageable by a tow when 90° crosswinds exceed approximately 30 knots.

Minor Mechanical Problems:

Under present starting procedures, the captain has maintenance personnel close at hand if mechanical problems develop. Mechanics are often called on to look at and/or correct minor discrepancies found by the captain before leaving the gate/ramp area.

Under the proposed regulations, maintenance personnel will not be readily available to lend assistance. The captain may decide to return to the gate (by towing) if a major mechanical item develops; but for minor items (such as fuel or oil quantity gauges, secondary instruments, etc.), he may decide to leave without further checking or confirmation.

Accidents are seldom the result of one failure or malfunction; they are usually the result of several items which compound one another to cause bigger unsolvable problems. One of these small mechanical failures may become one of the contributory factors in either an accident or an incident.

Congestion on the Ramp:

Congestion normally causes only delay, not accidents nor incidents. However, under the Massport towing regulation, it is possible that the congestion may have more serious consequences. First, the congestion will involve a wide variety of vehicles (including tugs, general aviation aircraft, and airline aircraft of both narrow-body and wide-body configurations), some of which will be taxiing and some under tow; mixing vehicles possessing broad performance variations will be difficult. Second, all airline aircraft will be operated under pressure to maintain schedules and beat the competition. Third, under some wind conditions, aircraft under tow will affect runway utility (and hence lead to overall airport delay) which will add additional pressure for expeditious handling. Third, the congestion will surround the firehouse which may inhibit the free movement of fire vehicles.

Congestion will also have its effect upon ground personnel. Mechanics on the tugs will be subjected to engine blast from nearby taxiing aircraft. Extended delay will affect the physical performance of ground personnel under extreme winter and summer temperatures. Noise from tugs and aircraft will muffle communications between the tug and both the cockpit and tower.

Tug Driver Performance:

This towing regulation will place substantially greater importance upon efficient, safe, and reliable tug operation. While current towing and push-back is under carefully controlled conditions and at low speed, the Massport

regulation would impose additional stress and importance on the towing function. The driver then becomes a more critical element of the system. This suggests such requirements as: additional training in towing, communications, terminology between pilots and the control tower, etc.; the probable need for licensing at least for communications; additional physical assurance such as through periodic examinations to an established standard; the possible need to provide oxygen to the tug for personal use during extensive holding when jet exhausts pollute the air; etc.

Tug Communications:

Although briefly discussed elsewhere, the question of communications reliability is important, and has added significance in this operation. Experience with tug communications sets has proven them to be less reliable than the on-board communication gear. Problems arise both with the equipment as well as with the cords connecting the headset with the jack mounted on the tug. Improved design of the cord and jack as well as better procedures to disconnect the cord (rather than simply pulling the cord) are needed. Obtaining full compliance by all maintenance personnel is envisioned as a continuing problem to maintain the integrity of the communications system.

Of additional concern is the fact that recent tests by Eastern personnel at Boston have indicated the existence of several "blind spots" on the ramp where communications between the tower and the tow vehicle are impossible. Certainly this matter affects the practicality of placing primary responsibility on the tug driver.

Aircraft Without Operative APU's:

There is some question as to the final interpretation of the Massport regulations concerning APUs on aircraft. One may interpret the regulations to require an operative APU before towing can be enforced; other interpretations suggest towing will be accomplished regardless of APU.

It is important that aircraft with passengers on board have an operative APU. Air conditioning in the summer and heating in the winter, an electrical power source for lights and other on-board equipment, and the ability to rely on an on-board system rather than a frangible power connection with the tug, all are important to achieving the goal of maximum ground safety and comfort for the passengers. A recent (limited) survey of one major airline's APU reliability indicates that approximately 5% of the APU's are inoperative. This is not an infrequent problem.

Engine Fire at Start:

Turbine engines have proven to be highly reliable during normal operations, as well as during start. It is infrequent today that there is a fire during engine start. However, even though infrequent, airlines still retain fire-fighting equipment in close proximity to the gate. Once an engine has been started, subsequent starts are safer since the system has already been checked for leaks.

The start at the transfer point (near the firehouse) would be the first start, and therefore somewhat more critical than subsequent starts (such as shutting the engine down to save fuel during extensive takeoff delays). An airline (or general aviation jet operator) would probable desire to have some form of fire-fighting equipment standing nearby, and personnel available to detect the fire at the earliest possible time. Massport personnel and equipment may satisfy this requirement for fire-fighting capability; however, plans must be evolved prior to initiating the revised procedure.

Consideration of such coverage should also include the firefighting agent itself. Discussions with several airlines have confirmed the fact that there is substantial variation in damage to the engine depending upon the foam or chemical involved. This matter has economic significance to the operator.

General Aviation Aircraft:

A large portion of the problems and hazards cited with respect to transport aircraft also pertain to the general aviation aircraft which will be subject to towing. The principal exception in terms of hazard is that concerning passengers where those in general aviation aircraft will not be able to move about.

The following two statements on towing were submitted by officials of two prominent general aviation organizations:

a. National Business Aircraft Association (Mr. W. M. Fanning, Manager, Technical Services)

(1) An exemption from the towing law should be obtained for all aircraft weighing less than 12,500 pounds. The engines required for the movement of these aircraft are small and do not generate appreciable noise.

(2) An exemption from the towing law should be obtained for all aircraft that do not have auxiliary power units (APU). To have to be towed with just the battery providing power would seriously deplete the battery depending upon the length of time of the tow. The aircraft would need the lights, radio, and perhaps some electric pumps on for the generation of hydraulic power. The APU would provide for all of the "on" items, plus heat and air conditioning, and would not negate the battery as a source of emergency power that it is intended for.

(3) Insurance. Which parties of the towing operation will have to provide adequate insurance to cover the aircraft, tug, people on board; the State which ordered the towing, the FAA which approved it, the owner of the tug providing the tow, and/or the operator of the aircraft being towed?

(4) All tugs used in the towing operaiton should be required to have a fluid coupling. This is necessary because of adverse stress that can accompany a jerky, rough start expected from a tug that is equipped with a manual clutch only. Towbars should be structurally sound for long-distance towing of fully loaded aircraft. The universal towbar would not be acceptable

for this type of operation. Insurance needs would also require a safe towing rig and would probably require a towbar which is recommended by the manufacturer of the aircraft.

(5) Communications from outside the aircraft to inside are not provided for in general aviation in the same manner as for air carrier aircraft. Some means of communication must be provided between the tug and captain of the aircraft being towed.

(6) Wing walkers should be required when the aircraft is being towed in a congested area, such as around the parking ramp or in the startup areas near the approach end of the runway.

(7) Procedures should be developed to take into account an aircraft that cannot get its engines started in the startup area or for some other reason has to abort the flight. Having to tow an aircraft down an active runway could present air traffic problems and delays in landing aircraft, increased fuel consumption, and noise by the aircraft which has to "go around".

(8) The captain of the aircraft should have the capability to disconnect from the tug if he sees his aircraft standing in danger. Under maritime law, a ship's captain always retains the right to command his ship, even when under the control of a harbor or docking pilot. The pilot or captain of the aircraft should never be required to relinquish his ultimate authority of command.

b. General Aviation Manufacturers Association (Mr. S. Green, Vice President)

"Regarding your telephone request about tow loads for general aviation turbine equipment, I hope the following is helpful.

"Estimated towing for typical general aviation turboprop and turbojet equipment is not warranted from a structural design point of view. Design tow-load factors are low, normally 1.15 times the expected loads. A typical load spectrum is based on one tow every other flight, with tow distances of approximately 20 yards on a relatively smooth, dry, level surface such as would be found in towing the aircraft from the hangar to the ramp. Towing long distances on taxiways would be extremely critical. Repeated instances of such towing will undoubtedly lead to nosegear failure."

Summary

This brief review of the safety aspects of Massport's proposed towing regulation outlines the many problems that may arise, especially from new and complicated procedures. The human element is stressed because the actions of individuals ultimately impact upon aviation safety, and recognizing the limitations of, and stresses upon, the individual is important in the design of aircraft and procedures. To those who ignore this fact, the industry has a motto "... If you need an accident to see that there is a problem, then you are part of the problem."

Finding solutions to a safety problem starts first with a complete definition of the problem and its many secondary issues. The issues presented in this report only start to bound the overall safety issue, and by no means represent either a full analysis of all safety matters nor a statement of solutions or alternatives. However, this Massport ruling is breaking new ground, and is bound to have national impact if adopted--and must be viewed in this broad perspective. Caution should be exercised in adopting new regulations which may affect aviation safety as these do. The extensive aviation expertise available in the industry must be brought to bear in the search for solutions before accidents show that there is a problem.

AIRLINES ACCIDENT DATA INVOLVING TOWING OPERATIONS

Airline A reports 12 incidents/accidents in 1976 involving the towing of aircraft. Four resulted in minor damage to aircraft and seven occurences of minor injury. The company reports one fatality in 1975 on push-back enroute to maintenance hangar.

Airline B reports two incidents, one at Boston and one at Washington National Airport. The incident at Washington involved a lead mechanic who suffered a severe coronary while towing an empty aircraft from gate to hangar. He managed to place the vehicle in neutral before losing consciousness and the mechanic in the aircraft succeeded in bringing the aircraft to a stop.

Airline C reports the following 39 incidents (table II-4) and 36 lost-time towing-related injuries (table II-5) for the period 1974 to 1976.

Table II-4. Airline C Towing Incidents

Date	Airport	Aircraft	Incident
1/20/74	LAX	DC-10	Being towed into gate--struck jet bridge.
8/16/74	LAX	B-727	Being towed into hangar--tail hit overhanging structure.
9/9/74	DCA	B-727	Being pushed-back--left wingtip hit parked Allied fueling truck.
10/25/74	JFK	B-707	Being towed--right wingtip struck hangar door.
10/9/74	SFO	B-747	Being towed--struck railing of scissor-bed truck.
10/2/74	LGA	B-727	Towbar pin and chain missing and not installed prior to towing aircraft--aircraft rode up onto towbar.

Table II-4. Airline C Towing Incidents - Continued

Date	Airport	Aircraft	Incident
12/22/74	JFK	DC-8	Maintenance used wrong towbar to push aircraft off gate--tractor cab struck radome.
12/14/74	ORD	DC-10	Being pushed back--tractor driver made premature turn, nose of aircraft struck jetway.
1/6/75	TULE	B-727	Being pushed into dock--tailpipe struck improperly positioned tail stand.
2/15/75	LAX	DC-10	Being towed from terminal to hangar with unweighted tractor--tractor partially jackknifed, steering cylinder contacted tractor.
2/3/75	JFK	B-323	Hough tractor being positioned for push-out--mechanic violated procedures and drove under wing between #3 and #4 engines, #4 engine thrust reverser damaged.
3/25/75	LGA	B-727	Being pushed out of hangar under direction of wing walkers--hit work stand, right wingtip bent.
3/13/75	PHX	B-727	Pushed back prior to brake release--broken nosegear door torque tube.
3/9/75	ORD	DC-10	Being positioned at hangar--was towed past the guide stoplines and hit overhead hangar structure, 1-foot hole in L/E vert. stop.
4/28/75	OKC	B-707	Being towed to gate by fleet service tractor due to hydraulic problems--struck by towbar.
4/19/75	PHL	B-727	Driver's door of Hough tractor opened--struck radome while operator was backing and turning into tractor well, 5-inch puncture in radome.
7/4/75	LGA	B-727	Tractor jackknifed on oil patch while backing aircraft from hangar parking area--rear corner of tractor punctured radome.
8/14/75	ORD	B-727	Being pushed back--struck low retainer wall, reverser and bottom of engine damaged.

Table II-4. Airline C Towing Incidents - Continued

Date	Airport	Aircraft	Incident
9/20/75	SAN	B-323	Being towed to washrack--hit construction barrier, 2x2 inch hole in #2 engine nose cowl.
9/19/75	JFK	B-747	Being towed--left elevator hit light pole.
11/24/75	BOS	B-727	Aircraft weathervaned during rain, snow, and gusty wind conditions--tractor jack-knifed, shear bolt sheared, towbar disconnected; struck aircraft, damaged nose gear brake assembly.
11/17/75	SFO	B-323	Being towed through construction area--outer edge of right wing contacted metal fence post, right wing aileron damaged.
11/15/75	BUF	B-727	Being prepared for push-back--mechanic's foot slipped off brake and hit accelerator, tractor moved forward shearing the shear bolts, causing nose gear vibration which caused failure of gear door bracket.
12/13 75	TULE	B-323	Hough tractor--struck aircraft's #2 engine T/R cowling.
2/27/76	ORD	B-747	Being pushed back from gate--#1 engine hit improperly parked tow truck, damaged engine cowl and thrust reverser sleeve.
2/21/76	DFW	B-727	Being pushed back with brakes set--nose gear torque bax attach points broken.
2/20/76	JFK	B-747	Being moved into bay 7--struck sliding platform on upper deck of nose stand which had not fully been retracted, fuselage damaged forward of emergency escape door.
3/5/76	JFK	DC-8	During push-out--tractor jackknifed, aircraft nose contacted cab, 6-inch puncture in right turbo compressor inlet duct.
3/2/76	LAX	DC-10	Being towed from terminal to hangar ramp--90° turn to parking spot was attempted. Aircraft did not follow after #4 wheel steering had been selected. Towbar bolts sheared. Nose steering cylinders L/H piston rod broken and R/H cylinder gouged.

Table II-4. Airline C Towing Incidents - Continued

Date	Airport	Aircraft	Incident
4/18/76	LGA	B-727	Being pushed out at hangar 5--wingtip struck top railing of workstand. Tractor driver failed to check area clearance, no contact with guideman.
6/25/76	SYR	B-727	Being pushed back with brakes set--towbar bolts sheared, aircraft nose gear door casting bracket broken.
6/12/76	PIT	B-727	Pushback completed and disconnect made--tractor driver placed gearshift into forward instead of reverse. Tractor struck and damaged nose wheel light bracket.
6/5/76	CLE	B-727	Being towed into hangar--left wing struck fence, 7x9 inch puncture in left wing #1 leading edge slat.
7/30/76	BUF	B-727	Tractor approaching towbar--driver hit accelerator instead of brake, aircraft nose gear door actuator tube assembly damaged.
7/9/76	YYZ	DC-10	Not being pushed back straight--mechanic failed to stop push-back, nose struck passenger loading bridge, 93-inch crease in fuselage below cockpit window.
8/25/76	BOS	B-323	Being pushed off gate--wingtip struck passenger loading stand.
8/18/76	JFK	B-747	Being towed into hangar--struck hangar wall, radome required replacement.
8/5/76	ORD	B-323	Being pushed out of hangar--right wingtip struck hangar wall.
10/9/76	SAN	B-707	Being towed to gate--struck DC-10 passenger stand that was improperly located. Mechanic failed to clear area. Three-inch tear in noise cowl #4 engine.

Table II-5. Airline C Employee Lost-Time Injuries (Towing)

Year	Head	Hands	Body/Back	Legs/Feet
1974		6	6	5
1975		2	5	6
1976	1	1	1	3
	1	9	12	14

Airline D reports the nine incidents listed below. There were no injuries sustained as a result of any of the incidents, but there were very close calls in two.

a. Sheared pins in towbar.

b. Damaged radome, nosegear position rod assembly, and both flex line fittings.

c. Forward entry door damaged.

d. Sheared towbar pins.

e. Sheared towbar pins.

f. Sheared towbar pins.

g. Sheared towbar pins.

h. Damaged left inboard training edge flap and inboard aileron and tab (collided with catering truck).

i. Damaged right wingtip trailing edge and light mast (collided with cleaning truck).

Airline E had developed two listings, one providing towing incidents by type of aircraft for 1975 and 1976 (table II-6), and the other for a much longer period showing DC-9 damage incurred while being towed (table II-7).

Table II-6. Airline E Towing Incidents

Date	Airport	Incident
		B-727
11/26/76	ATL	Towbar adapter lug broken--replaced lug.
5/7/76	ATL	Towbar broke--replaced damaged torque link.
2/13/76	ATL	Towbar broken--replaced towbar.
		DC-9
2/5/76	JAN	Towbar damaged nosegear tire--replaced right nosewheel assembly.
2/25/76	CVG	Towbar pin broken--removed broken pin.
3/31/76	ATL	Towbar damaged tire--replaced right nose tire and wheel assembly.
		DC-8
		None
		L-1011
3/20/76	ATL	Hydraulic tube pulled from steering manifold during tow.
6/10/76	ATL	Towbar broke--replaced both nose tires.
5/14/75	ATL	Towing accident--replaced transfer tube and bracket.
12/22/75	BOS	Tug jackknifed--replaced steering collar.
		B-747
		None

Table II-7. Airline E DC-9 Fleet Damages

Date	Incident
1/2/72	On push-back on slick surface--tug jackknifed, damaging radome, nose section of fuselage, and nose gear door.
2/21/74	During push-back--brakes failed on tug, truck struck radome and nose gear door of aircraft.
9/19/71	On push-back--towbar broke, tug struck radome.
4/13/74	While being towed for repositioning--ship struck cabin service lift truck, hole in leading edge of outboard slat.
1/12/73	While being towed to parking pad--towbar broke, tug hit nose of aircraft, hole in fuselage.
5/8/73	During tow from pad to gate--aircraft ran over uneven surface, nose gear twisted past stop, nose gear damaged.
6/14/74	During push-back--towbar broke, nose gear damaged.
	On push-back--ship hit parked bag cart, wingtip damaged.
7/31/71	During towing from hangar area to line--left-hand wingtip hit building.
9/9/67	During towing operations--aircraft struck line maintenance truck, left-hand wing damaged.
7/3/70	Relocating DC-9 to gate 69--towbar broke, tug hit radome and fuselage.
6/12/68	During push-back from gate--aircraft struck fuel truck.
12/22/75	During towing out of snow-covered ramp--towbar broke, tug jackknifed and hit ship.
5/23/73	On push-back--ship was hit by aircraft taxiing into gate.
7/27/71	During towing to line from hangar--ship struck cabin service vehicle when swinging into gate, tail cone damaged.
5/7/76	On push-back from gate--ship hit a parked fuel truck.
9/18/70	While repositioning ship at gate with tug--ship struck a parked cart.
6/9/75	During towing from hangar to line--towbar broke, tug hit ship.

Table II-7. Airline E DC-9 Fleet Damages - Continued

Date	Incident
4/21/72	Being pushed into ship 213 parked parallel at ORD--right-hand bottom of wing of ship 251 damaged.
4/17/73	Being towed on rain-slick surface--tug jackknifed, nose gear door damaged.
3/13/71	During push-back--brakes failed on tug, tug hit radome.
5/10/72	During towing operations--the towbar broke in a left turn, aircraft struck tug damaging fuselage.
9/8/74	During pushback--aircraft struck a parked fuel truck, #1 engine damaged.
12/4/74	While repositioning aircraft--hit terminal building, left-hand elevator and stabilizer damaged.

Airline F reports the following 39 incidents (table II-8) in terms of aircraft damage caused by towing and the number of lost-time, towing-related injuries for 1976 (table II-9).

Table II-8. Airline F Aircraft Damage Caused by Towing

Date	Airport	Incident
2/3/76	JFK	Being towed to gate for departure--right wing went over the top of left wing on aircraft 332, 22-inch scratch on bottom side of wing.
3/16/76	MIA	Being towed to gate B-2--tractor operator temporarily blinded by sun, pushed aircraft into baggage cart, 24-inch crease in wing to fuselage fairing.
5/10/76	LGA	Maintenance tow crew damaged right wingtip of aircraft 535 and left aileron of aircraft 517 while preparing to move aircraft to gate. Aircraft 535 had right navigation light cover cap bent and lens broken; wingtip skin wrinkled. Aircraft 517 had left aileron bent with three, 3/4-inch punctures on leading edge.
6/1/76	JFK	On push-out after disconnecting towbar from aircraft and tractor--right front wheel of tractor ran over towbar, towbar struck aircraft causing 4x3 inch tear in left forward gear door.

Tale II-8. Airline F Aircraft Damage Caused by Towing - Continued

Date	Airport	Incident
6/7/76	JFK	After push-out--towbar was disconnected. Tractor backed up and pulled forward, rolling over towbar. Towbar bounced up striking right forward nose gear door: 2x3 inch hole in door.
7/16/76	JFK	Towbar fight pin bent and slipped out on pushout. Left side of towbar struck left rear gear door. Door had aft corner torn. Door buckled and bent.
9/1/76	ATL	During pushout--towbar bolt sheared. Towbar struck taxi light. Taxi light and support bracket broken.
10/14/76	MIA	While towing aircraft to gate for departure--#1 engine nose cowl struck jetway at gate C-10, engine cowl flattened and buckled approximately 12 inches wide at leading edge.
11/24/76	EWR	Towbar broke where lock pin goes into wheel nut--both nose gear flying doors bent, 1x3 inch rear lower edge rolled up.
11/7/76	BOS	During pushout--towbar came loose from nose strut, nosegear strut scraped just below boss of drag strut attach point, right door lower aft edge bent over 5-inch area.
12/30/76	ATL	While maintenance was turning tractor around to push aircraft to gate--fueler hooked up hoses. Aircraft pushed to gate with hoses connected. Both fuel flange nozzles broken at wing panel.
12/27/76	ORD	Push-out started with lavatory truck still attached to aircraft. Aircraft pushed into truck. Left engine aft lower cowl dented 12x20x1 inches deep. Dump connection bent.

Table II-9. Airline F Employee Lost-Time Injuries (Towing)

Date	Airport	Injury
1/3/76	JFK	Contusion, left foot. During hookup of L-1011 towbar, co-worker released valve causing towbar to drop and strike employee's foot.
1/4/76	DCA	Fractured elbow while stepping over towbar. Left foot slipped on ice causing employee to fall on left elbow.
1/17/76	TPA	Severe strain, lower back. Hooking up towbar, employee felt pain in back.
2/3/76	BOS	Low back strain. Used a towbar with a defective pump. Lifted bar manually to attach to lug.
2/6/76	DCA	Injured great toe, left foot. Installing towbar on tractor. Employee slipped on ramp and bar fell on foot.
2/7/76	ORD	Injury to left knee. Employee was in squatting position installing pin in towbar axle. Left knee popped.
2/1/76	FLL	Injury to left knee. Employee and co-worker were hooking up towbar to aircraft. Towbar misaligned causing one pin only to engage. The other pin went under lug. Co-worker bounced the bar up and down while another employee held tension on release handle trying to remove bar from aircraft lugs. Towbar came loose and struck employee's knee.
2/13/76	SJU	Back pain. Lifted DC-8 towbar to hook it up to aircraft. Felt pain in back.
4/29/76	LGA	Cracked bone, spine. Hooking towbar to aircraft.
5/29/76	EWR	Fracture of bone, right foot, and possible phlebitis. Disconnecting 727 towbar from tractor. Towbar fell on foot.
7/26/76	PHL	Felt strain in back while connecting towbar.
9/12/76	ORD	Abrasion, contusion right foot. Hooking up tow-bar to tractor. Employee signaled tractor driver to move forward. Instead of going forward, the tractor driver went backward. Towbar dropped off tractor and fell on employee's foot.

Table II-9. Airline F Employee Lost-Time Injuries (Towing) - Continued

Date	Airport	Injury
5/26/76	MIA	Hernia. Connecting towbar to aircraft.
9/14/76	SJU	Strain, lower back. Removing B-727 towbar.
10/23/76	EWR	Sprained shoulder and neck while hooking up towbar to DC-9 aircraft. Mechanic was pulling on bar to insert left pin into nose wheel. Pin released suddenly causing injury.
11/21/76	ATL	Twisted back while hooking up towbar to 727 aircraft at gate 2.
12/12/76	BOS	Dorsal strain. While employee was hooking up towbar to L-188 aircraft in Bay 4, possibility that a slight off balance condition occurred causing injury.
12/19/76	ATL	While connecting towbar to aircraft at concourse A, employee was exerting force on bar when he lost footing and fell on bar. Contusion to chest wall.
12/23/76	JFK	After disconnecting L-1011 towbar and getting into cab of tractor, employee felt sharp pain in low back and right leg. Unable to bend or lift without pain in back.

Another airline reports:

12/23/70	ACFT No. 786	Four-inch hole and skin damage when aircraft jackknifed on icy surface and contacted tug.
4/12/71	DC-8	Aircraft pushed back into blast fence. Damage included hole in skin 34x18 inches. Two longerons and one stringer brace severed.
10/73	DC-8	Lead mechanic killed during DC-8 push-back from parking spot. Deceased walking alongside nose-gear failed to note aircraft was turning.

Airline G reports that it has approximately 98,900 towing and push-out operations and 275,200 taxi operations. These are performed by both flight operations and maintenance personnel. In 1976, they had four aircraft damage accidents related to towing and push-out operations and three aircraft damage accidents related to taxiing. The conclusion being that towing and push-outs are liable to cause a higher number of ground accidents by a factor of 3.7 than taxi operations.

Airline H advises that specific records of towing accidents are not maintained. However, they report the following incidents for 1976 (not all but those they could assemble from available records).

a. At JFK, a 707 was being towed from the cargo facility. The ground conditions were icy. The observer, who was wearing the headset in contact with the cockpit, slipped on the ice and fell down. The tractor driver removed his foot from the gas pedal and the engine stalled. The tractor then began to slide toward the left wingtip and the towbar broke. The tractor driver attempted to restart the Paymover but was unable to do so. By this time, the airplane had passed over the Paymover. The Paymover was to the left and in close proximity to the fuselage. As the left body gear door approached the tractor, the driver jumped from the unit to avoid injury. The aircraft hit the Paymover at the entry where the driver sits, and the aircraft stopped. Both the aircraft and the Paymover experienced damage.

b. During the past 2 years, Detroit has had two towbar disconnections on 727-type aircraft. These occurred while towing aircraft over snowy ramps. The roughness of the surface permitted the lock pin to bounce out of the towbar, permitting the locking handle to disengage. In both cases the tractor driver instinctively slowed the tractor down, and subsequently the aircraft ran over the towbar, damaging the towbar and the nosegear of the aircraft.

c. Although this incident was not directly concerned with towing for long distance, it does depict the critical nature of towing aircraft. Recently during a push off from a gate position at ORD from an icy ramp with one engine operating, a DC-10 slid sideways and contacted another DC-10 at an adjacent gate. This was caused because the Paymover was slipping, and another carrier's 707 jet blast impinged on the tail of the DC-10.

Airline I reports that during 1976 they had one towing accident which resulted in two DC-9 aircraft making contact and causing damage to both aircraft.

Airline J provides the following summary of towing incidents incurred during 1975 and through January 1977.

Table II-10. Airline J Towing Accidents

Date	Airport	Aircraft	Incident	Extent
3/12/75	SFO	747	Towbar sheared during towing	Hazard
4/10/75	ANC	707	Struck stand during tow	Damage
7/23/75	GUM	707	Struck stand during tow	Damage
9/1/75	LAX	747	Struck stand during tow	Damage
12/9/75	RIO	707	Towed with ground power hooked up	Damage

Table II-10. Airline J Towing Incidents - Continued

Date	Airport	Aircraft	Incident	Extent
12/2/75	JFK	747	Aircraft rolled after towbar disconnect	Damage
1/6/76	LAX	747	Struck loading ramp during tow	Damage
2/24/76	JFK	747	Unattended tow vehicle rolled into aircraft	Damage
2/25/76	BER	727	Struck stand during tow	Damage
3/12/76	TPE	747	Struck by towing vehicle	Hazard
3/27/76	SFO	747	Struck stand during towing	Damage
5/19/76	SFO	747	Struck loading ramp during tow	Damage
7/13/76	CPH	747	Struck loading ramp during tow	Damage
8/8/76	JFK	707	Struck hangar door during tow	Damage
9/19/76	LAX	707	Struck stand during tow	Damage
12/2/76	LAX	747SP	Struck stand during tow	Damage
12/11/76	LON	707	Struck stand during tow	Damage
1/4/77	BRU	727	Struck vehicle during tow	Damage
1/28/77	IAH	707	Aircraft struck by tow vehicle	Damage

Airline K advises they perform very little towing and have not recently had a towing accident. However, several years ago they averaged four to five towing accidents per year when their policy called for the towing of aircraft for maintenance purposes.

Airline L reports a total of 13 tractor/aircraft damage incidents in 1976 and no injuries.

Airline M performs very little towing except for relatively short distances in LAX. They incurred three incidents in 1976 of broken towbars which caused aircraft damage.

Airline N reports bolt shearing problems on towbars while towing. Additionally, high winds and surface ice conditions have caused a B-737 to slide sideways some 40 to 50 feet. The F-27 is difficult to tow under winter conditions (winds and ice).

The following comments are a compilation from member carriers regarding aircraft towing in general and are provided for consideration.

° During a push-back/tow operation, ground marshallers/guides tend to be more relaxed, less alert, perhaps because the engines are not operating.

° Communications between cockpit and ground are sometimes minimal.

° Vision between ground guides and marshalers is often limited, especially at night and during certain weather conditions.

° It is difficult for guides to relay warnings to the marshaler or to the man in charge of the operation. This results in delayed warnings that often cause the accident to happen while the man assigned to prevent same stands helpless.

° The cockpit crew usually is completely out of the response loop since they normally cannot see what is going on down below.

° Towing aircraft at heavier gross loads will increase the frequency of towbar shear-pin failures and the resultant exposure to personnel injuries and aircraft damage.

° Cabin temperatures in non-APU equipped aircraft might become very uncomfortable during any extended towing operation.

° Extended towing of a fully fueled airplane with passengers increases exposure to hazard.

° There will be increased congestion as well as hazard for the drivers of the additional tractors, GPU's, and start trucks operating over larger expanses of the airfield.

° Increases in towing frequence/duration will result in increased aircraft damage experience, increased employee lost-time injuries, inordinate wear on nosegear axles and steer collars, and in reduction in schedule reliability due to towing delay/problems.

SECTION III

OPERATIONS AND CAPACITY IMPLICATIONS OF THE MASSPORT TOWING REQUIREMENTS

INTRODUCTION

It is claimed in exhibit A, Recitals, Facts, and Conclusions of the 1976 Additions to Airport Rules and Regulations, prepared by the Massachusetts Port Authority, that the proposed towing regulation "will not unduly disrupt operations." Operations will be disrupted, however, and the nature and the extent of these disruptions are identified and examined here.

PRESENT OPERATIONS

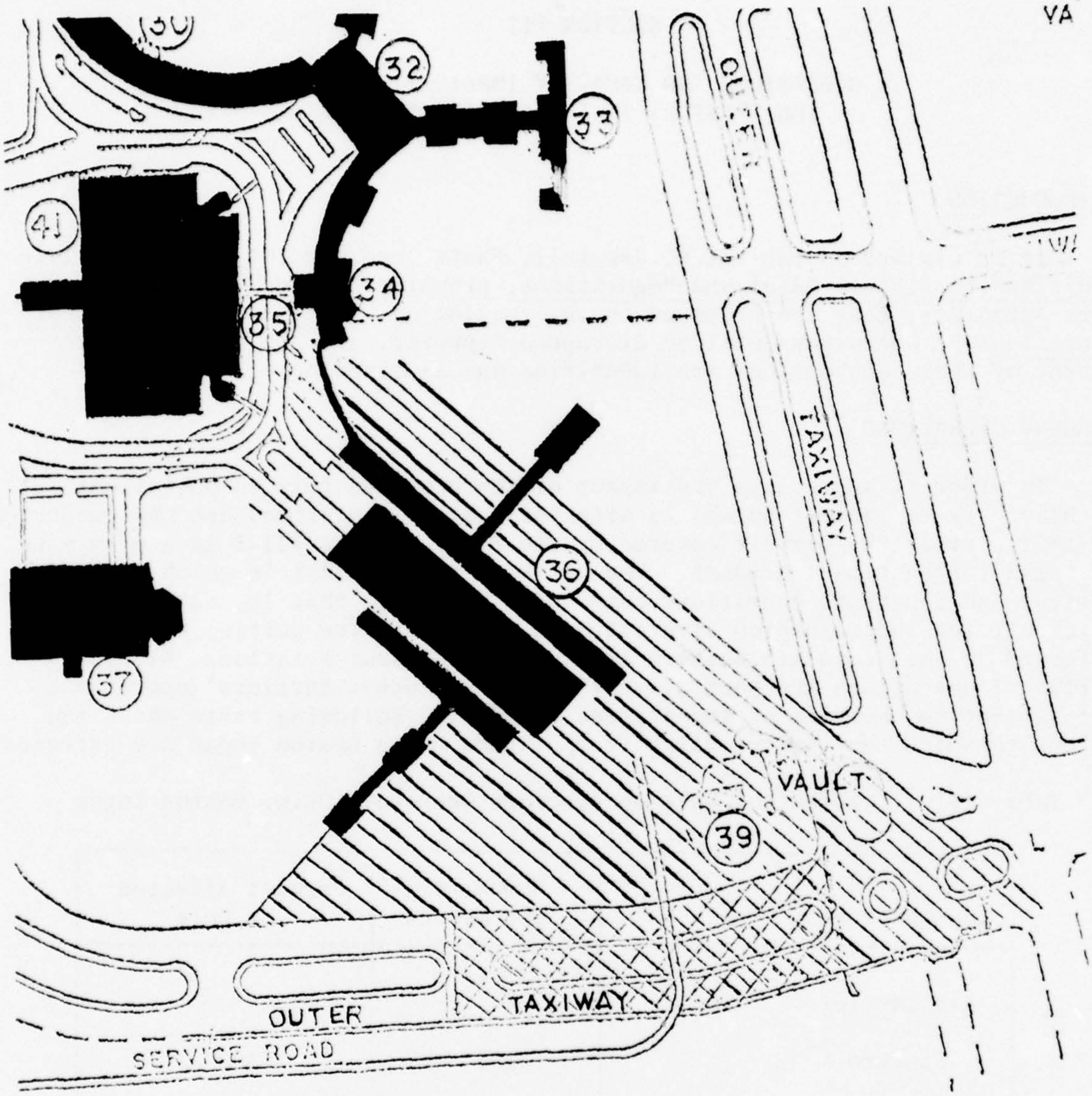
In order to appreciate the impact of the proposed rule on operations, it is necessary to understand who is affected and how operations are now conducted in that part of the airport covered by the rule. Figure III-1 is a plan view of Logan International Airport. The unshaded area is that in which aircraft arrival and departure operations come under the rule, that is, the area in which all jet and turboprop aircraft must be towed. The parties particularly affected by this rule are Eastern Airlines and General Aviation. Allegheny Airlines' operations are partially affected. No other carriers' operations are subject to the rule at the present time. The following table shows the extent to which the various aircraft operators using Boston Logan are affected.

Table III-1. Effect of Rule on Aircraft Operators Using Boston Logan

Operator	Number of Operations	Percent Affected by Rule
Air Carrier		
Eastern	108	100
Allegheny	92	43
Other	365	0
Air Taxi	95	0
Other GA	108	50
Military	3	?

(Source: GRA)

Arrival operations for scheduled aircraft are presently quick and simple. The sequence of operations shown in table III-2 is as follows: Aircraft land, enter the taxiway system, and then move under their own power to a gate at the



Region of airport exempted from towing rule

Transfer zone

36 South (Volpe) Terminal

37 Eastern Airlines Terminal

39 Fire station

Figure III-1. Plan View of Logan International Airport

terminal building. At the gate, the aircraft stops and shuts down its engines, a passenger-boarding bridge is positioned at the aircraft door, and passengers are then free to enter the terminal.

Table III-2. Present Arrival Sequence

Event	Activity
Aircraft Passes Firehouse*	Taxi In
Aircraft Stops at Terminal	

*Figure III-2 shows the firehouse with an L-1011 just behind it on the outer taxiway.

(Source: GRA)

Departures are only slightly more complicated. Because aircraft are designed only to move forward under their own power, either the terminal building must be designed to permit an aircraft to power away from it after the passenger-boarding bridge has been removed, or the aircraft must be pushed back and away from the terminal building until there is sufficient forward way clearance to allow it to maneuver away from the building under its own power. Allegheny's terminal is of the former type; aircraft generally power-in and power-out. Eastern's terminal is such that aircraft must be pushed back on departure. General Aviation aircraft power-in and power-out.

During push-back, the aircraft may be positioned into the wind to facilitate aircraft engine starting. This is particularly important for Eastern's L1011 aircraft; airline operating experience has shown it to be sensitive to wind direction and speed on start-up.

The sequence of operations for a typical Eastern departure is shown in table III-3. The captain obtains clearance for aircraft departure from the control tower using the ground control radio frequency. Two radio contacts between captain and tower are usual. When the aircraft is ready to depart and while it is still at the gate, the captain requests permission to begin the push-back. Although this is not an obligatory contact, it is a normal operating procedure which, in the opinion of the FAA controllers, would continue under the proposed towing rule. After being cleared for push-back, the captain informs the tractor driver by means of a separate closed circuit (hard-wired) link between aircraft and tractor, and push-back begins. (Figures III-3 to III-6 show details of the aircraft-tractor connection.)

From the beginning of the push-back and until the captain is notified by the push-back crew that the aircraft is free to taxi, the operation is under the control of the tractor driver. After the push-back is complete and the aircraft is ready to taxi, the captain contacts the tower for permission to enter and use the taxiway system.

Eastern uses a four-man ground crew for push-back: three mechanics and one ramp service man. One mechanic drives the tractor. The other two handle

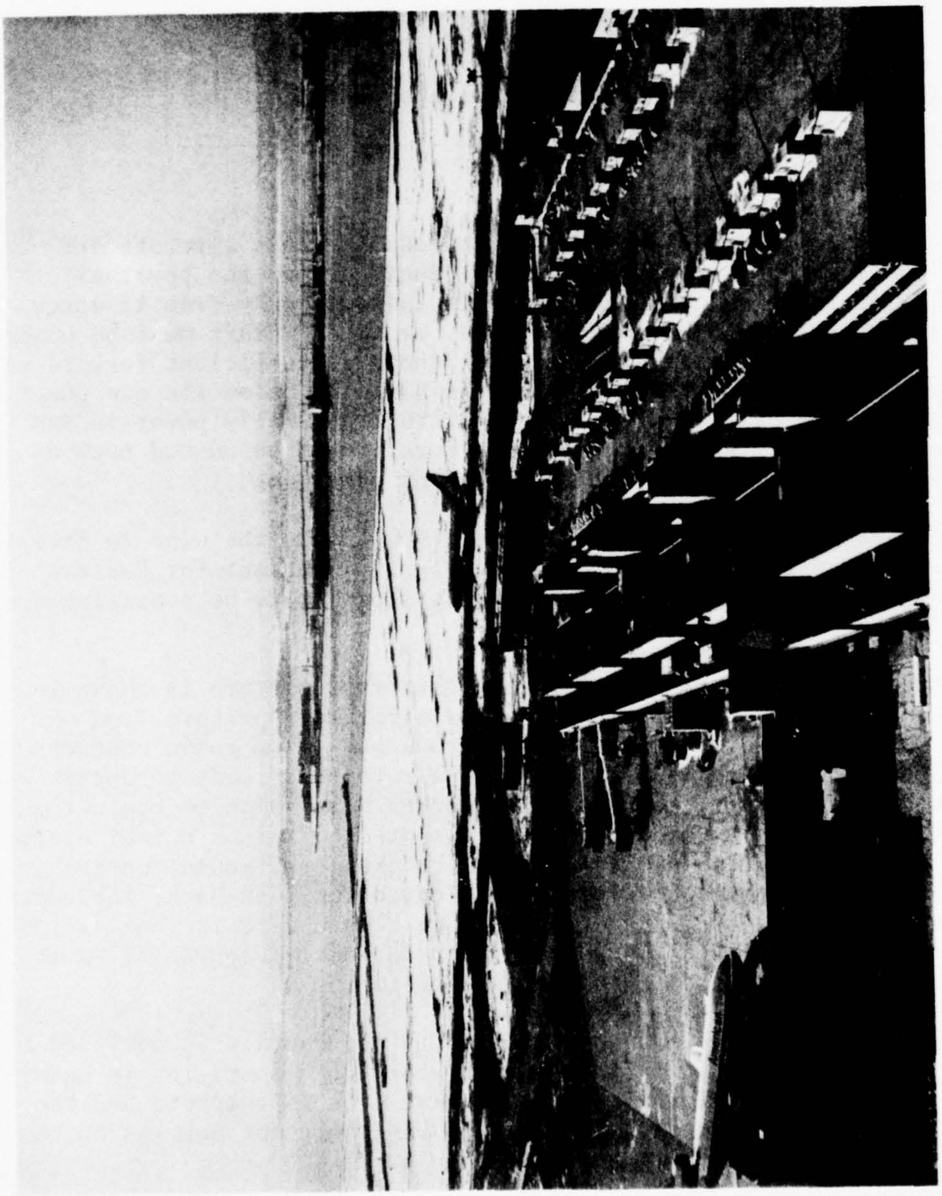


Figure III-2

Table III-3. Departure Sequence at Present

	Event	Activity
1.	Tractor assigned to aircraft	
2.	A. Tractor connected to aircraft	
	B. Communication established between tractor and aircraft	Hook up (5 minutes)
	C. Torque links disconnected	
3.	Aircraft scheduled to depart	
		Schedule Delay
4.	Clearance requested for push back	
		Tower Delay
5.	Clearance to push back received	
		Push Back
6.	Push back complete	
7.	Engines started*	
	Pilot requests clearance to taxi	
	Torque links connected	Engine start and tractor disconnect
	Two bar disconnected	
	Tractor/A.C. communications link disconnected	
	Signal given to start taxi	

*Starting of B727 and DC9 engines is begun during push back. Starting of L1011 engines usually begins after aircraft is pushed back and faced into wind.

(Source: GRA)

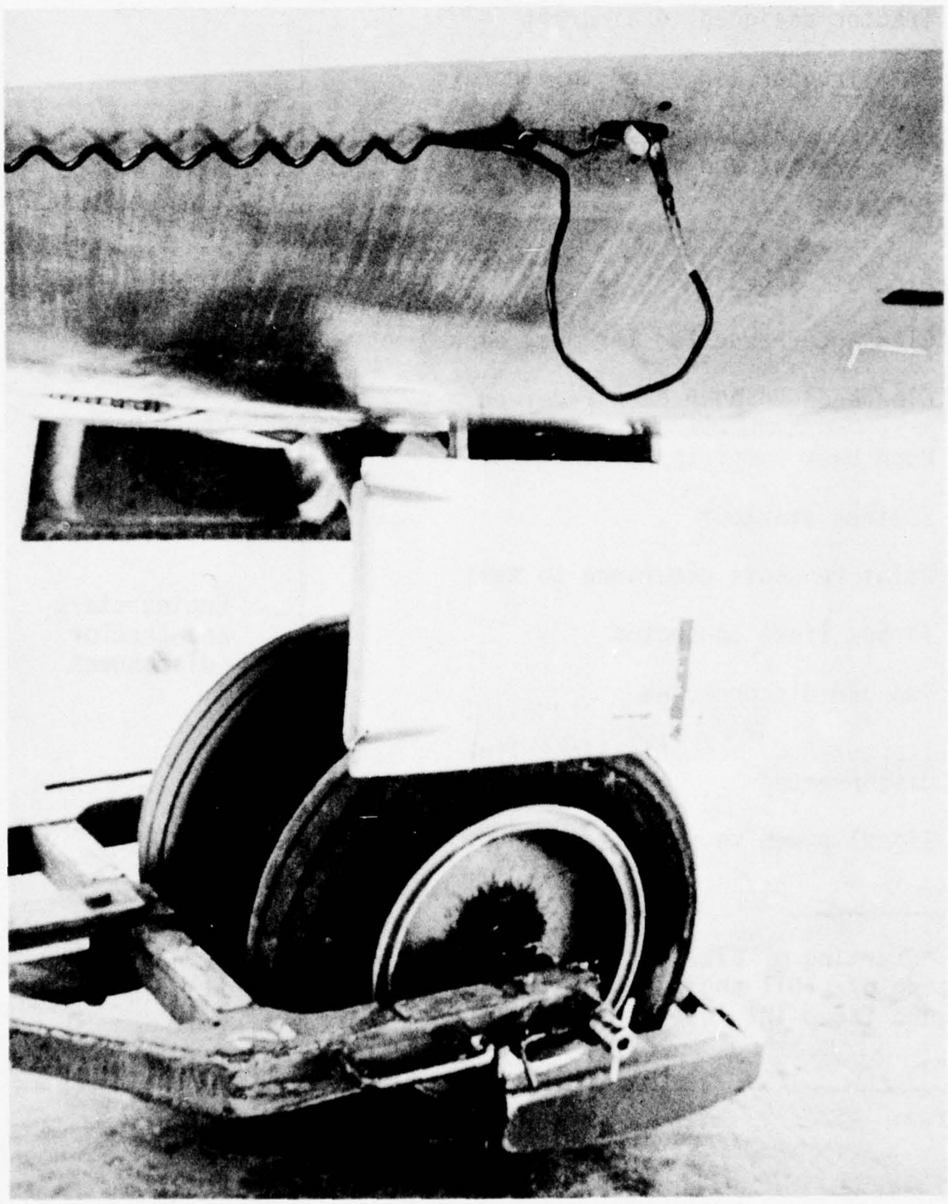


Figure III-3. Detail of Aircraft-Tractor Connection

Figure III-4. Detail of Aircraft-Tractor Connection

Figure III-5. Detail of Aircraft-Tractor Connection

Figure III-6. Detail of Aircraft-Tractor Connection

the tractor-to-aircraft connect and disconnect operations and signal to the driver during push-back if any unsafe clearances occur between aircraft wing tips and other objects. The ramp service man signals to the captain when the push-back operation is complete and the aircraft may proceed to the taxiway.

Eastern Airlines presently has six tractors (five T-300's and one T-500) to handle its 108 daily operations plus routine maintenance tows at Logan.

The design of Allegheny's terminal and the size of the aircraft in its fleet (DC-9 and BAC-111) make it possible for their aircraft normally to power-in and power-out. In this case, only one captain-to-control tower contact is necessary prior to entering the taxiway system. Occasionally, off-schedule operations leads to double parking of aircraft at the gates and push-outs are necessary. When this happens, the size of the aircraft makes it possible for two mechanics to handle a push-back.

General aviation aircraft power-in and power-out from their parking area. One pilot to tower contact is required prior to taxiing; no ground personnel are necessary.

The following conclusions concerning the present operation can be drawn from the above descriptions:

° On departure, aircraft are cleared to begin taxiing prior to entering the taxiway.

° At most, two pilot-initiated radio contacts are required prior to entering the taxiway on departure. One pilot-initiated tower contact is required after the aircraft enters the taxiway system.

° The pilot of an aircraft is in command and in control of the aircraft at all times after the aircraft leaves a ramp area.

° No aircraft engine startups take place on taxiways.

° All passengercarrying aircraft on taxiways are under power.

° All aircraft on a taxiway can move at approximately the same speed on the taxiway.

° The sequence of aircraft on a taxiway has little or no effect on the average speed of aircraft moving on the taxiway.

° No tractors operate on the taxiways.

° No tractors are used on arrivals.

° No tractors leave their own ramp as part of normal arrival and departure operations.

° The number of tractors and ground crew personnel is a minimum consistent with safe and economic operations.

° Aircraft starting time is minimized by positioning aircraft into the wind on push-back.

° An aircraft can be returned to the terminal building quickly with a minimum inconvenience to its passengers and without delaying the departure or arrival of other aircraft, in the event that an engine fails to start, or any other cause of flight delay, or cancellation occurs after push-back.

° Maintenance costs of tractors and of aircraft landing gear is at a minimum with respect to the design and location of the terminal building.

° Aircraft ground times are a minimum consistent with staffing, schedule consideration, and aircraft ground servicing operations.

PROPOSED RULE

Article V of exhibit B of the 1976 Additions to Airport Rules and Regulations defines an Aircraft Operating Movement as; "Any movement of jet or turboprop aircraft on the ground directly to or from a runway in connection with a takeoff or landing by that aircraft."

The proposed rule requires that:

"Within the daily time periods established by the following compliance schedule, no aircraft operating movement (except for arrivals or departures from South Terminal gates 4, 6, 8, 10, 12, and 13 shall be conducted by self-propulsion westerly of an area near the Airport Fire Station designated by the Airport Manager as the area for towing initiation (inbound) or towing termination (outbound).

"Compliance Schedule: Departing Aircraft

Commencing February 1, 1977--Midnight to 7:00 a.m.
Commencing April 1, 1977--11:00 p.m. to 7:00 a.m.
Commencing July 1, 1977--7:00 p.m. to 7:00 a.m.

"Commencing January 1, 1978 this regulation shall apply to departing aircraft twenty-four hours per day. The Executive Director upon notice to be given not later than November 30, 1977 based on a finding that an extension is necessary to permit implementation of the program without undue congestion or delay, may extend until June 30, 1978 the commencement date for twenty-four hour application of this compliance schedule.

"Compliance Schedule: Arriving Aircraft

Commencing February 1, 1977--Midnight to 7:00 a.m.
Commencing July 1, 1977--11:00 p.m. to 7:00 a.m.
Commencing October 1, 1977--7:00 p.m. to 7:00 a.m.

"Commencing January 1, 1978, this regulation shall apply to arriving aircraft twenty-four hours per day. The Executive Director upon notice to be given not later than November 30, 1977 based on a finding that an extension is

necessary to permit implementation of the program without undue congestion or delay, may extend until June 30, 1978 the commencement date for twenty-four hour application of this compliance schedule."

The exclusion of operations from South Terminal gates 4, 6, 8, 10, 12 and 13 is incorrect. Operations from these gates come under the rule. Operations from all other South Terminal gates are excluded. Massport acknowledges this.

OPERATION UNDER PROPOSED TOWING RULE

The proposed towing rule requires that, within specified daily time periods, all jet and turboprop aircraft arriving into or departing from the areas affected by the rule be towed. The area for initiating towing of arriving aircraft and terminating towing of departing aircraft, which will be referred to as the "transfer zone", is shown in figure III-1 as the hatch-lined region.

Table III-4 shows the sequence of events on an arrival. The tractor would be dispatched from the terminal building approximately ten minutes prior to the

Table III-4. Arrival Sequence Under Proposed Rule

Event			Activity
1.		Tractor and Crew assigned	
2.	A.	Tractor and crew leave terminal for transfer zone	Preparations to receive arriving aircraft (10 min.)
	B.	Tractor and crew at transfer zone	
3.		Aircraft expected in transfer zone	Schedule delay
4.	A.	Aircraft arrives in transfer zone	
	B.	Engines stopped	Tower delay
	C.	Tractor requests clearance to enter transfer zone	
5.	A.	Clearance to enter zone received	
	B.	Tractor enters zone	
	C.	Connect tractor/aircraft radio link	Hook up
	D.	Connect tow bar	
	E.	Disconnect torque link	
	F.	Clearance to tow requested	
6.	A.	Clearance to tow received	Tower delay
	B.	Tow begins	Towing
7.		Aircraft parked at terminal	Unhook
8.		Tractor ready to reassign	

(Source: GRA)

estimated time of arrival of the aircraft at the transfer zone. The tractor would be equipped with a two-way radio operating on the ground control frequency and the driver would contact the tower for clearance prior to entering onto a taxiway. At some point within the transfer zone, an inbound aircraft stops and shuts down its engines. It waits for a tractor and towing crew to enter the taxiway, to connect the tractor to the aircraft nose wheel, to connect the aircraft to tractor communication links, and to begin the towing to the terminal building. The tow ends when the aircraft is at a gate and in position to disembark its passengers through a loading bridge as in the current operation.

The sequence of events on departure is shown in table III-5. After receiving clearance from the tower to begin push-back, the aircraft is pushed into a safe position from which to begin towing. The tower is then contacted for clearance to begin the tow and enter the taxiway system. The aircraft is then towed to the transfer zone.

In the transfer zone, the aircraft will be maneuvered into a favorable position for starting its engines if the wind direction and speed make this necessary. After startup, the ground crew disconnects the tractor and reconnects the nose gear torque links. When this operation is complete and the aircraft is ready to taxi, the tractor driver will contact the tower for clearance to leave the taxiway and return to the terminal building on the service road. The pilot will subsequently request clearance to begin taxiing.

The proposed rule will have the following effects:

a. More tower contacts on the ground control frequency and the increased possibility of delays in initiating contact.

b. Longer aircraft travel time between runway and terminal, and terminal and runway.

c. Larger ground crew and tractor assignment times on departures.

d. New assignments for ground crews and tractors on arrivals.

e. Increased tractor traffic on the service roadway adjacent to the taxiways, resulting in increased aircraft-to-ground vehicle interference.

f. Exposure of tractors to jet blast on taxiways.

g. Additional delays in returning aircraft to the terminal building if engines will not start or experience other malfunctions in the transfer zone.

EFFECTS OF PROPOSED RULE ON AIRLINES AND AIRPORT OPERATIONS AND COSTS

The proposed towing rule will have the following general effects:

a. Longer aircraft travel time on arrival and departure of all aircraft subject to the rule and of some aircraft exempt from the rule.

b. Longer tractor and crew assignment times on arrivals and departures.

Table III-5. Departure Sequence Under Proposed Rule

Event			Activity
1.	Tractor assigned to aircraft		Hook up (5 minutes)
2.	A.	Tractor connected to aircraft	
	B.	Communications established between tractor and aircraft	
	C.	Torque links disconnected	
3.	Aircraft scheduled to depart		Schedule delay
4.	Clearance requested for push back		Tower delay
5.	Clearance to push back received		Push back
6.	Push back complete		
	Clearance to tow requested		Tower delay
7.	Clearance to tow received		
	Tow started		Towing and positioning aircraft for starting
8.	Aircraft stopped in transfer zone		Start up
9.	Engines started		
	Torque links connected		
	Tow bar disconnected		
	Communications link disconnected		
	Tractor requests clearance and returns to terminal		
10.	Clearance to return received		Tower delay
	Tractor returns to terminal		
	Pilot requests clearance to taxi		
11.	Clearance to taxi received		Tower delay
	Taxi begins		

Source: GRA

c. Increased use of ground control radio frequency.

The causes and consequences of these general effects are as follows:

Longer Aircraft Travel Time

The longer travel times of towed aircraft on the ground on arrival and departure arise from two sources.

First, a tractor with an aircraft in tow moves slower than an aircraft under its own power. Table III-6 shows results of a towing experiment conducted by Eastern Airlines (EA) at Logan between January 1 and January 12 of this year.

Table III-6. Summary of EA Towing Test Data

Tow-Out Operation (Mean Time Data--Minutes)

Type A/C	No. of Obs.	Towing[1] Time	Startup Time	Total[2] Time	Tractor[3] Time
DC9	7	9.10	1.60	10.70	15.10
727	6	10.00	2.20	12.20	15.00
L1011	6	11.70	10.70	23.00	26.50

Tow-In Operation (Mean Time Data--Minutes)

Type A/C	No. of Obs	Towing[4] Time	Hookup Time	Total Time	Tractor[5] Time
DC9	4	8.25	1.25	9.50	19.20
727	5	7.40	1.80	9.20	24.80
L1011	4	6.50	3.75	10.20	24.20

[1] Includes time to pushback.
[2] From beginning of pushback to start of taxi.
[3] From beginning of pushback to return of tractor to terminal.
[4] From start of tow to stop at terminal.
[5] From dispatch at terminal to return to terminal.

(Source: GRA)

These times were subsequently corroborated by the contractor on the night of February 23 in a towing test conducted with the cooperation of Eastern Airlines. In this latter test, three aircraft -- a DC9, a 727, and an L1011 -- were pushed back from the terminal building and towed to the firehouse in a simulation of operations under the proposed rule. The aircraft were empty of passengers, but fully fueled. The results of this test are shown on table III-7.

Table III-7. Results of February 23 Towing Test Tow-Out Operation

Type A/C	Weight (lbs.)	Push-back Time (min.)	Tow Time (min.)	Total Time (min.)
DC9	79,280	2.9	7.30	10.2
727	134,000	2.10	7.25	9.25
L1011	312,100	5.3	5.3	9.2
(Source: GRA)				

In order to compare the towing times measured by Eastern with those obtained by the contractor on February 23, it is necessary to remove push-back time from the Eastern observations. Table III-8 gives push-back time observations made by the contractor on February 23.

Table III-8. Push-back Times--Current Operations

	DC9	727	L1011
	69 sec	136 sec	437 sec.
	87	77	303
	65	137	
	66	73	
Sum	287 sec	423 sec.	740 sec.
Mean	1.2 min.	1.75 min.	6.2 min.
(Source: GRA)			

Subtracting the mean push-back time shown in table III-8 from the Eastern tow-out times of table III-6 leads to the following comparison of tow-out times (excluding push-back and engine startup times):

A/C	EAL	Feb. 23
DC9	7.9	7.3
727	8.2	7.25
L1011	5.6	5.3

The two sets of observations agree within the variability of the data.

Combining the push-back time estimates for DC9 and 727 aircraft with the mean out bound taxi time data computed in table III-9 from measurements made by GRA gives estimated mean outbound times under the current rules. Table III-10 shows the comparison of these with the estimates used by Eastern.

Table III-9. Observed Taxi Times (In Minutes)--Current Operation (Excluding L1011)

	Allegheny*	Eastern East Side	Eastern West Side	General Aviation
	INBOUND TAXI TIMES			
	1:19	1:55	2:05	3:35
	1:25	1:25	2:30	3:05
	1:29	1:40	2:25	2:40
		1:35	1:35	3:15
		2:23	1:30	1:50
		1:55	2:40	2:55
		2:08		3:22
				3:45
Sum	4.22	13.02	12.75	24.45
No. Obs.	3	7	6	8
Mean	1.41	1.86	2.12	3.04
	OUTBOUND TAXI TIMES**			
	2:30	3:35	3:00	3:15
	1:15	3:30	3:40	2:50
	1:47	1:35	3:16	2:45
	1:50	1:33	2:14	
	2:04	2:37	2:34	
	2:14	2:17		
		3:01		
		2:48		
Sum	11.68	20.43	14.73	8.83
No. Obs.	6	8	5	3
Mean	1.95	2.55	2.95	2.94

*From affected gates only
**Timed from beginning of taxi. Excludes push-back

(Source: GRA)

Table III-10. Current Travel Times--Outbound

A/C	Push-back (min.)	Taxi (min.)	GRA Total	Eastern
DC9	1.2	2.75	3.95	4
727	1.75	2.75	4.50	4
L1011	6.2	3.8	10.0	10.3
(Source: GRA)				

GRA and Eastern both estimate that current operations take 2 minutes inbound from the firehouse. Estimated travel time increases are therefore approximately as follows:

Type A/C	Inbound Increase (min.)	Outbound Increase (min.)
DC9	8	7
727	7	8
L1011	8	12

The second cause of longer travel times is delay caused by aircraft queueing in the transfer zone while awaiting their turn to start engines. Let engine start time be the elapsed time between the termination of towing in the transfer zone and the beginning of the forward motion of the aircraft under its own power. Then clearly, if all departing aircraft use the outer taxiway (figure III-1), the total outbound towing time of every aircraft in an outbound taxiway queue is increased by the sum of the engine start times of all the aircraft ahead of it in the queue at the time it joins the queue and the time it takes to tow the aircraft to the starting point from the point at which it first joined the queue.

The effect of queueing on trip time is illustrated in appendix F, Simulation of Operations Under the Proposed Towing Rule. As might be expected, very few queueing delays occur in the time period between 1900 and 0700. Substantial delays do occur, however, between 0700 and 1900. Delay data obtained from the queueing simulation is summarized in tables III-11 and III-12. The time intervals used in the summary correspond to those given in the Compliance Schedule of the Towing Rule and represent the incremental effects of the Towing Rule on operations that will be experienced as the rule is extended over time. Tables III-13 and III-14 aggregate the incremental effects and is an estimate of the total delays and delay minutes that will be experienced as the rule is extended.

Table III-11. Summary of Daily Arrival Operations

Operator	OPNS	Tows	Queueing Delays	Delays Minutes
		0000-0700		
EA	3	3	0	0
AL	0	0	0	0
GA	8	4	0	0
Total	11	7	0	0
		2300-0000		
EA	4	4	1	2
AL	3	1	0	0
GA	3	1	0	0
Total	10	6	1	2

Table III-11. Summary of Daily Arrival Operations - Continued

Operator	OPNS	Tows	Queueing Delays	Delays Minutes
		1900-2300		
EA	13	13	1	2
AL	9	4	1	2
GA	15	10	0	0
Total	37	27	2	4
		0700-1900		
EA	43	43	6	13
AL	34	17	9	19
GA	73	33	14	63
Total	150	92	29	95

(Source: GRA)

Table III-12. Summary of Daily Departure Operations

Operator	OPNS	Tows	Queueing Delays	Delays Minutes
		0000-0700		
EA	3	3	1	3
AL	2	1	1	3
GA	9	2	0	0
Total	14	6	2	6
		2300-0000		
EA	0	0	0	0
AL	0	0	0	0
GA	3	1	0	0
Total	3	1	0	0
		1900-2300		
EA	10	10	6	35
AL	6	4	3	15
GA	21	10	5	41
Total	37	24	14	91

Table III-12. Summary of Daily Departure Operations - Continued

Operator	OPNS	Tows	Queueing Delays	Delays Minutes
		0700-1900		
EA	48	48	17	58
AL	36	18	17	96
GA	64	28	27	128
Total	148	94	61	282

(Source: GRA)

Table III-13. Summary of Arrival Operations

Operator	OPNs	Tows	Queueing Delays	Delay Minutes
		0000-0700		
EA	3	3	0	0
AL	0	0	0	0
GA	8	4	0	0
Total	11	7	0	0
		2300-0700		
EA	7	7	1	2
AL	3	1	0	0
GA	11	5	0	0
Total	21	14	1	2
		1900-0700		
EA	20	20	2	4
AL	12	5	1	2
GA	26	15	0	0
Total	58	40	3	6
		0700-0700		
EA	63	63	8	17
AL	46	22	10	21
GA	99	47	14	63
Total	208	132	32	101

(Source: GRA)

Table III-14. Summary of Departure Operations

Operator	OPNS	Tows	Queueing Delays	Delays Minutes
		0000-0700		
EA	3	3	1	3
AL	2	1	1	3
GA	9	2	0	o
Total	14	6	2	6
		2300-0700		
EA	3	3	1	3
AL	2	1	1	3
GA	12	3	0	0
Total	17	7	2	6
		1900-0700		
EA	13	13	7	38
AL	8	5	4	18
GA	33	13	5	41
Total	54	31	16	97
		0700-0700		
EA	61	61	24	96
AL	44	23	21	114
GA	97	41	32	169
Total	202	125	77	379

(Source: GRA)

Tables III-15 and III-16 show simulated activity in the transfer zone between 1800 and 1826 hours. Each column represents the activity of a single aircraft. Column headings show the type of operation: TOW (towed) or POW (powered), the operator: EA (Eastern), AL (Allegheny), or GA (General Aviation) and the type of aircraft. The figures in each column are the distance from the firehouse in feet. Positive distances are west of the firehouse, negative distances are east of the firehouse. The queueing delay figure at the bottom of a column is the total queueing delay in minutes experienced by the aircraft. This time slice dramatically illustrates the formation and persistence of queueing involving both towed and taxiing aircraft in the area west of the firehouse, the "normal" additional taxiway time of aircraft operations under the proposed rule, and the extended periods of tractor utilization.

It is informative to compare this example with an example of outbound queueing included in appendix F. In the latter, the queue could be reduced if the tower chose to clear outbound aircraft by Using both the inner and outer taxiways. The situation illustrated here does not lend itself to such a solution.

A visual presentation of the information of tables III-15 and III-16 is given in figures III-7 through III-20, inclusive. The time reference is shown directly below the South Terminal. Inasmuch as the boundaries of the transfer zone have not been formally designated nor have specific rules governing the initiation or termination of towing in the zone been set forth, the visual presentation assumes that all inbound and outbound towing transitions take place adjacent to the Fire and Crash Station.

Two other sources of delay and taxiway congestion are the occasional necessity to return aircraft to a gate after push-out because of engine start failure (table III-17) and the positioning of Eastern's L1011 (and occasionally their 727 aircraft) for engine startup. The next two figures (figures III-21 and III-22) illustrate a situation that occurred during Eastern's towing study. Figure III-21 shows an L1011 on the ramp adjacent to the firehouse where it was towed in order to position it into the wind for engine startup. Inbound Eastern, Allegheny, General Aviation, American, and Delta aircraft were held on the inner taxiway in order to allow the L1011 to return to the taxiway system after startup (figure III-22).

The effect of longer aircraft travel times on scheduled service and airline revenues is discussed at length in section IV.

GATE HOLD PROCEDURES

It is difficult to identify, much less analyze, all the implications of the Massport towing proposal as far as the gate hold procedures in effect at Logan International Airport are concerned. (See Appendix G, Gate Hold Procedures.) These procedures, evolved over the last several years, were designed specifically "as an aid to the critical fuel situation" following the events of November 1973. Moreover, the gate hold procedures have apparently reduced "significantly" the "amount of aircraft noise and fuel emissions" that impact

Table III-15. Sequence #2 Inbound Under Proposal Rule 1759-1826

Time of Day	TOW EA DC9	POW GA Prop	POW GA Prop	TOW EA DC9	TOW EA L1011	TOW GA Jet	TOW GA Jet	TOW GA Jet	TOW AL DC9	TOW EA 727	POW GA Prop
1759	0										
1800	0	-200	-400	-600	-800						
1801	400	200	0	-200	-400						
1802	800	600	400	0	-200						
1803	1200	1000	800	0	-200						
1804	1600	1400	1200	400	0						
1805	2000	1800	1600	800	0	-200	-400	-600			
1806	2400	2200	2000	1200	0	-200	-400	-600			
1807	2800	3900	3700	1600	0	-200	-400	-600			
1808	3000	5600	5400	2000	0	-200	-400	-600			
1809	3400	-	-	2400	400	0	-200	-400			
1810	-	-	-	2800	800	0	-200	-400			
1811	-	-	-	3200	1200	400	0	-200	-400		
1812	-	-	-	3600	1600	800	0	-200	-400		
1813	-	-	-	-	2000	1200	400	0	-200		
1814					2400	1600	800	0	-200		
1815					2800	2000	1200	400	0		
1816					-	2400	1600	800	0	-200	
1817						2800	2000	1200	400	0	
1818						3200	2400	1600	800	0	
1819						3600	2800	2000	1200	400	
1820						4000	3200	2400	1600	800	0
1821						4400	3600	2800	2000	1200	1000
1822						4800	4000	3200	2400	1600	1400
1823							4400	3600	2800	2000	1800
1824								4000	3200	2400	2200
1825								4400	3600	2800	3900
1826									-	3200	-
Queueing Delay	0	5	5	2	4	4	7	8	4	1	3

(Source: GRA)

Table III-16. Sequence #2 Outbound Under Proposal Rule 1759-1826

Time of Day	TOW EA DC9	TOW GA Jet	TOW EA 727	TOW EA DC9	POWER GA Prop	EA DC9	EA DC9
1759	0	2500					
1800	0	2000					
1801	0	1500					
1802	-	1000					
1803	-	500	2800	3350			
1804	-	0	2400	2850			
1805	-	0	2000	2350			
1806	-	0	1600	1950			
1807	-	-	1200	1550	1875		
1808	-	-	800	1150	1475		
1809	-	-	400	750	1075		
1810	-	-	0	350	675		
1811	-	-	0	350	675		
1812	-	-	0	350	675		
1813	-	-	-	0	325		
1814	-	-	-	0	325		
1815	-	-	-	0	325	2000	2305
1816	-	-	-	-	-	1500	1845
1817	-	-	-	-	-	1000	1325
1818	-	-	-	-	-	500	825
1819	-	-	-	-	-	0	325
1820	-	-	-	-	-	0	325
1821	-	-	-	-	-	0	325
1822	-	-	-	-	-	-	0
1823	-	-	-	-	-	-	0
1824	-	-	-	-	-	-	0

(Source: GRA)

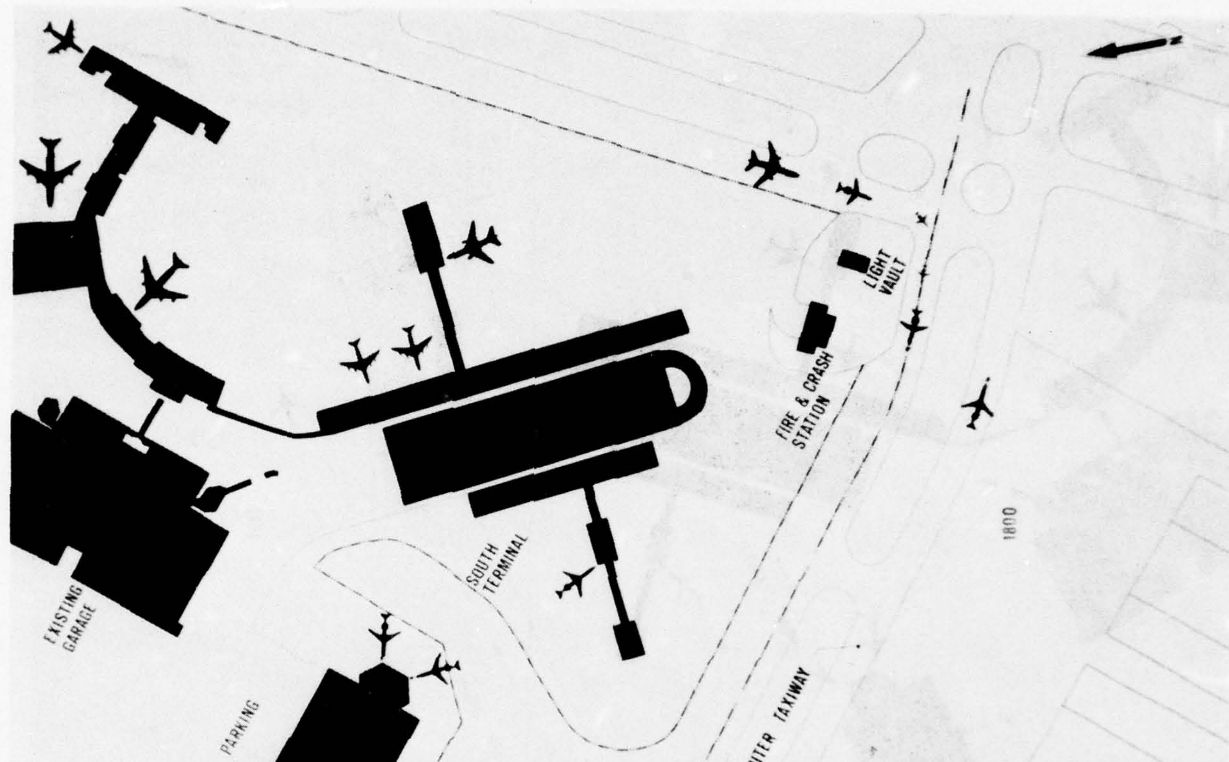
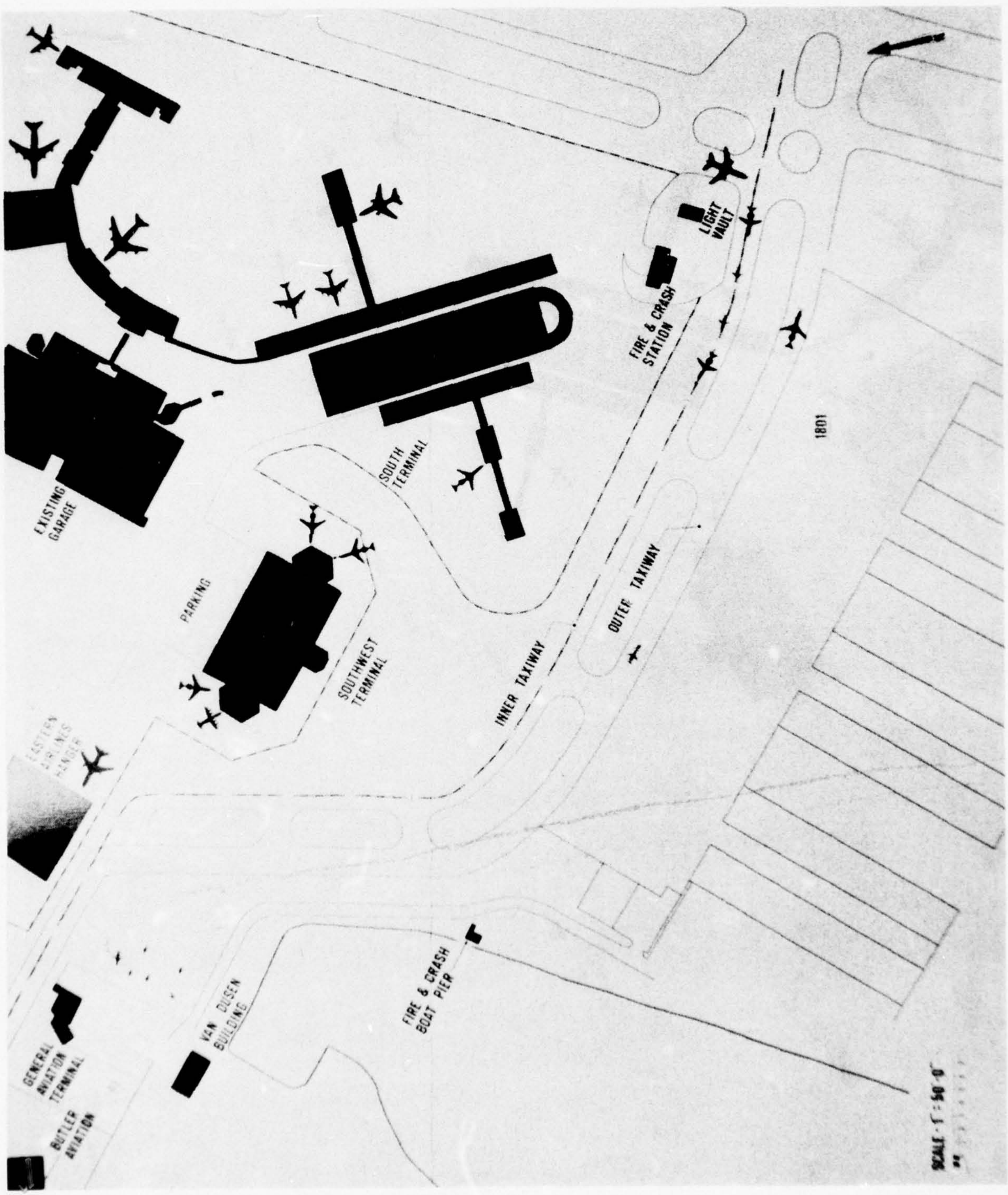

EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
FIRE & CRASH STATION
LIGHT VAULT
INNER TAXIWAY
OUTER TAXIWAY
1800
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE 1" = 50' 0"

Figure III-7



LIGHT VAULT
FIRE & CRASH STATION
SOUTH TERMINAL
EXISTING GARAGE
PARKING
SOUTHWEST TERMINAL
OUTER TAXIWAY
INNER TAXIWAY
1801
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure III-8


EXISTING GARAGE
SOUTH TERMINAL
LIGHT VAULT
FIRE & CRASH STATION
PARKING
SOUTHWEST TERMINAL
INNER TAXIWAY
OUTER TAXIWAY
EASTERN AIRLINES HANGER
1803
VAN DUSEN BUILDING
FIRE & CRASH BOAT PIER
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure III-9

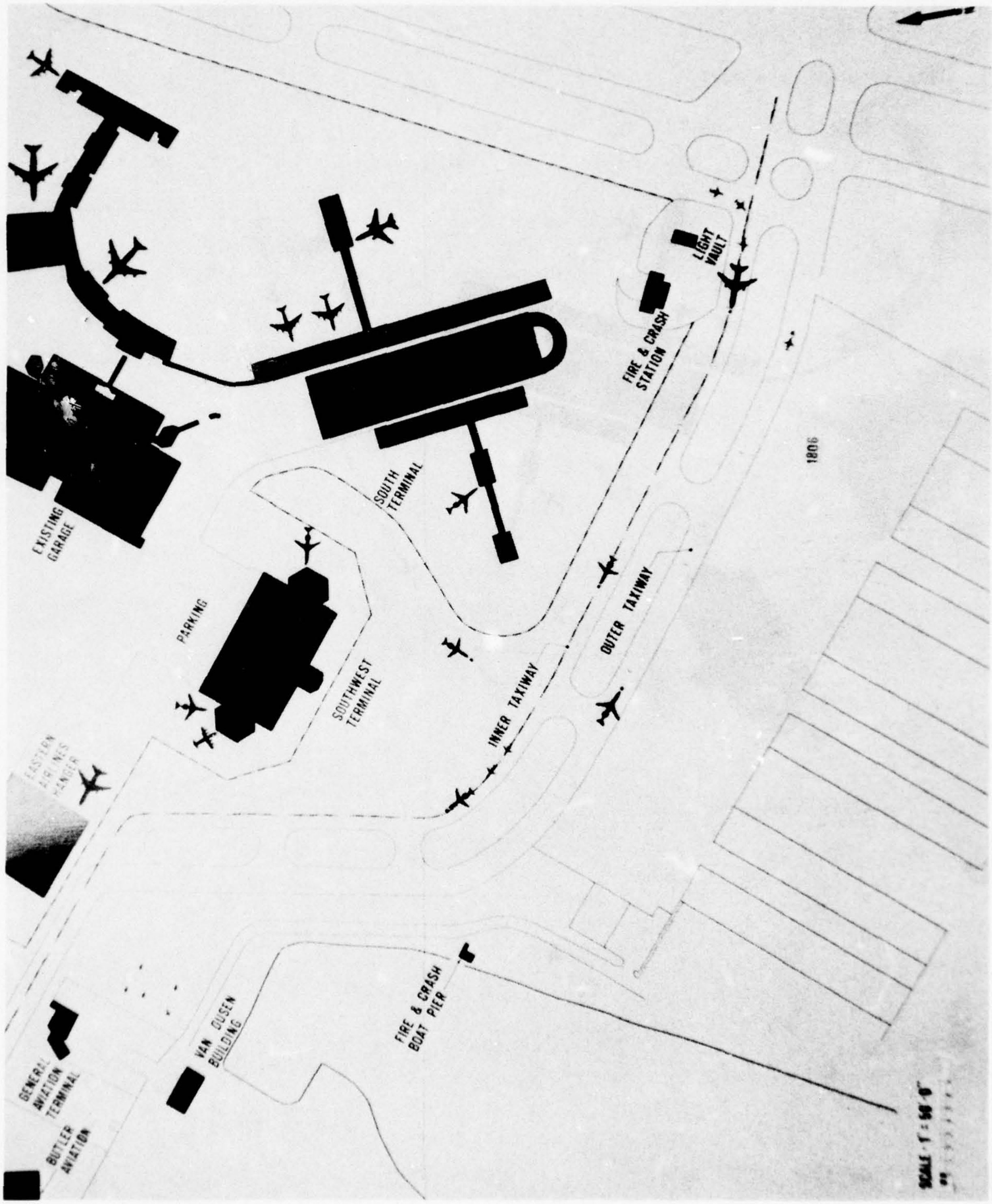


Figure III-10

Figure III-11

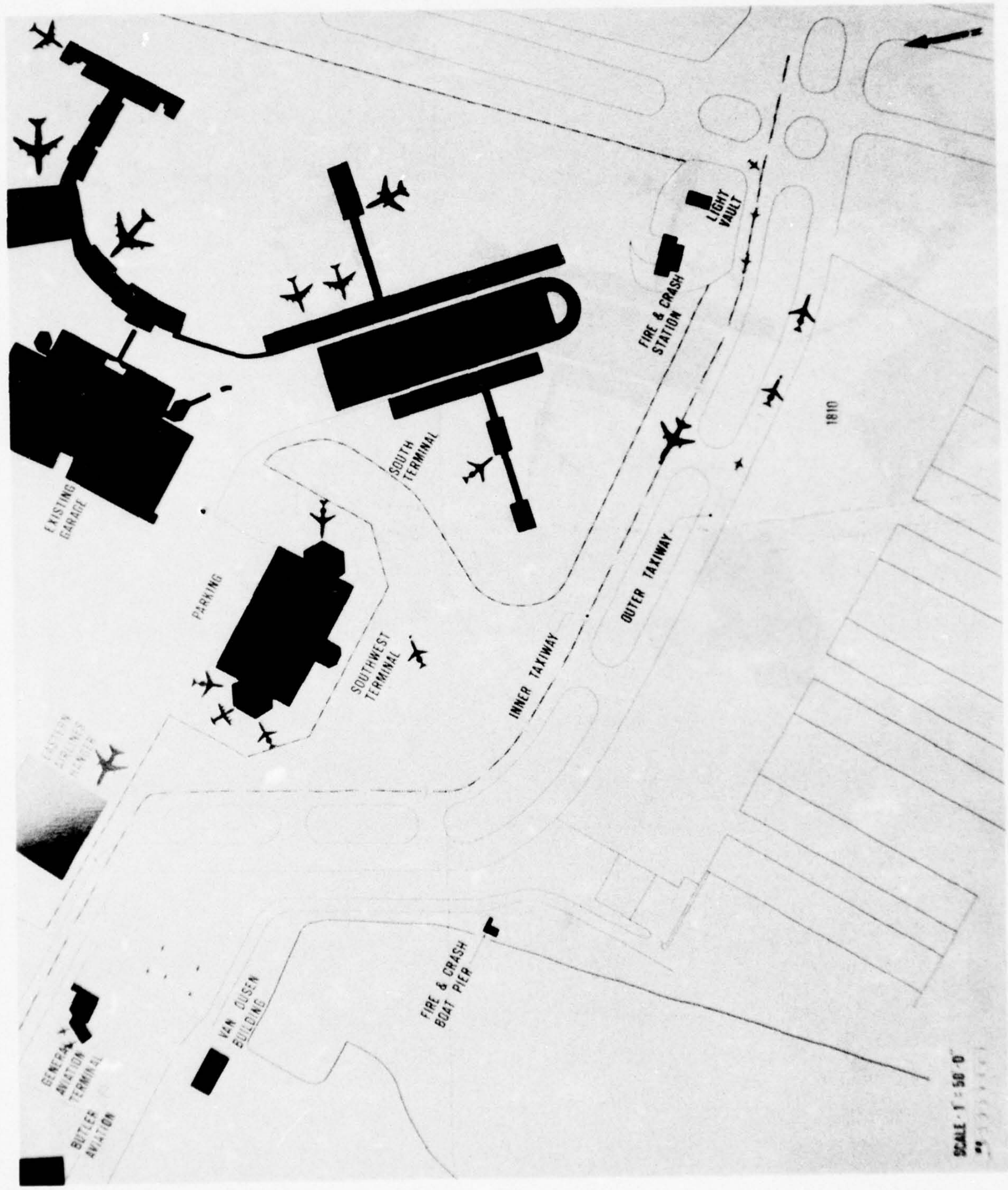


Figure III-12

Figure III-13

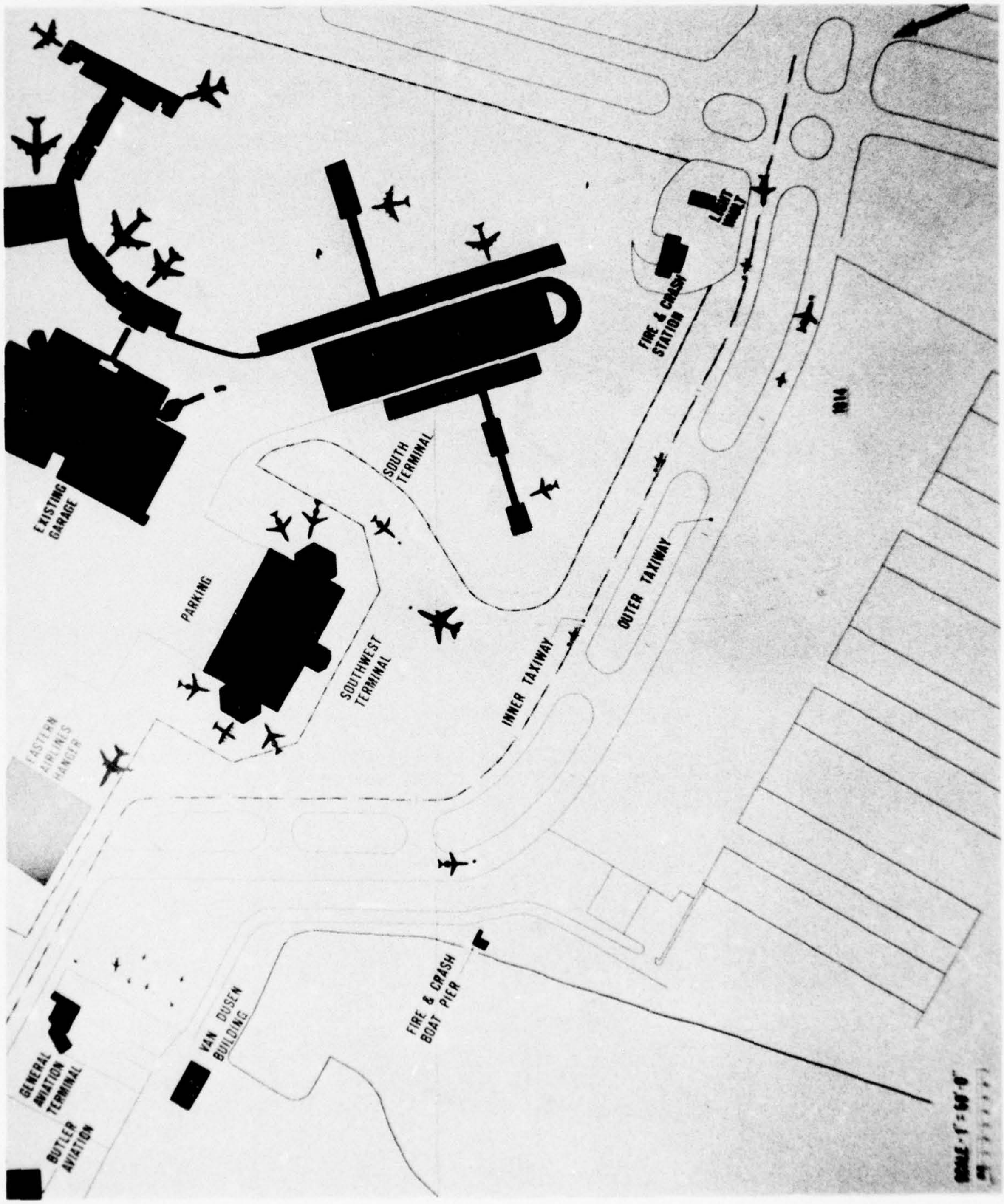


Figure III-14

Figure III-15

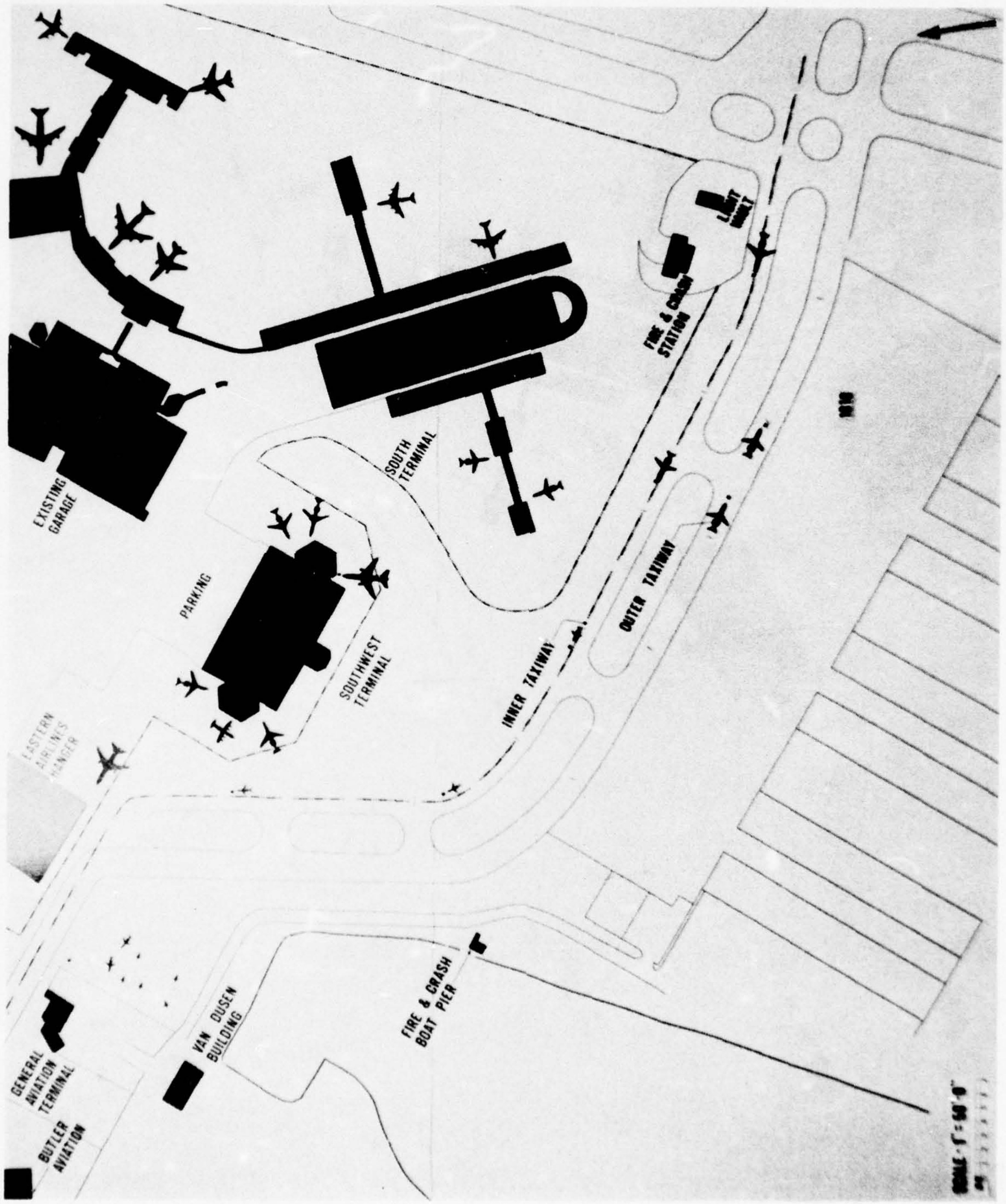


Figure III-16

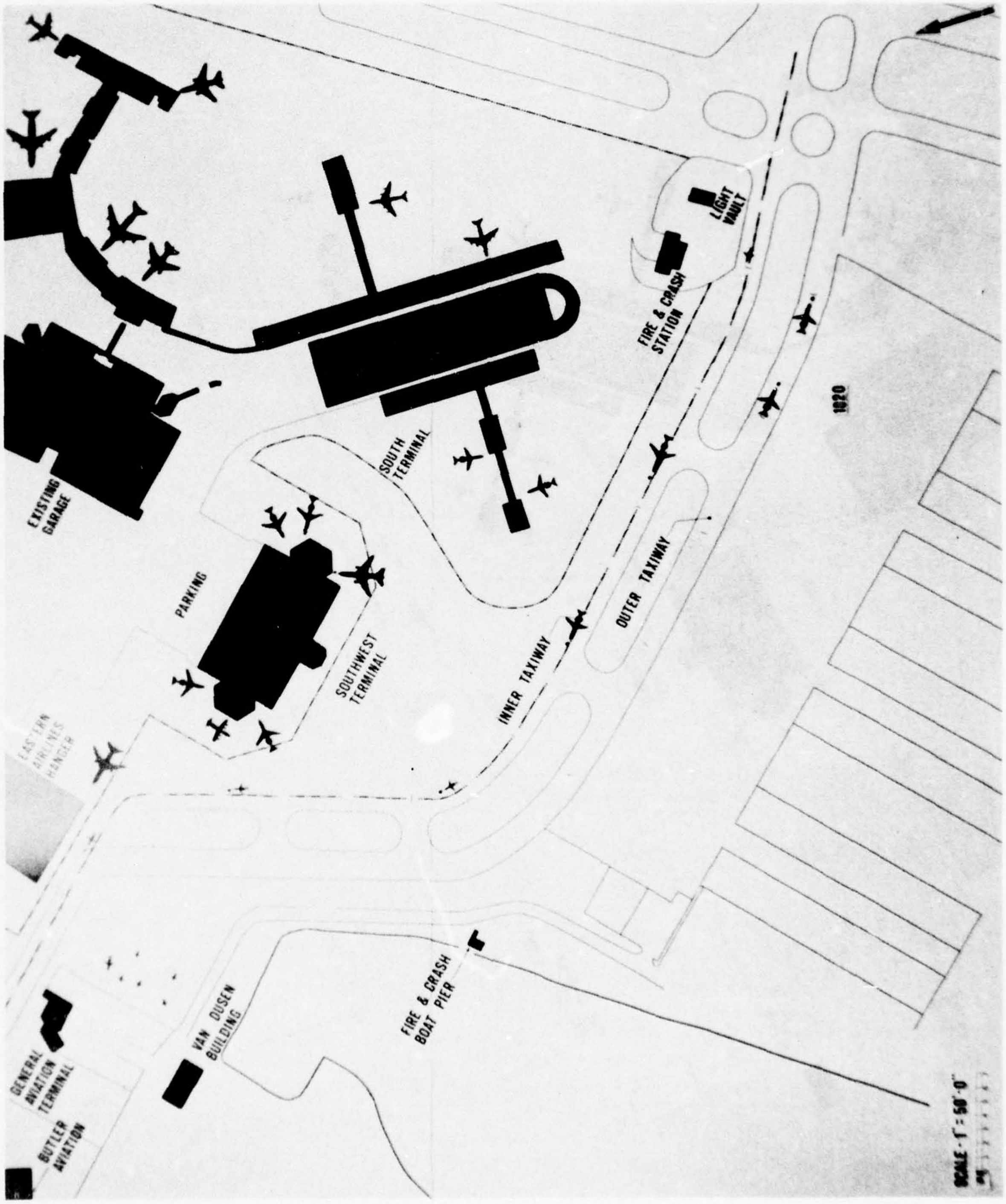


Figure III-17

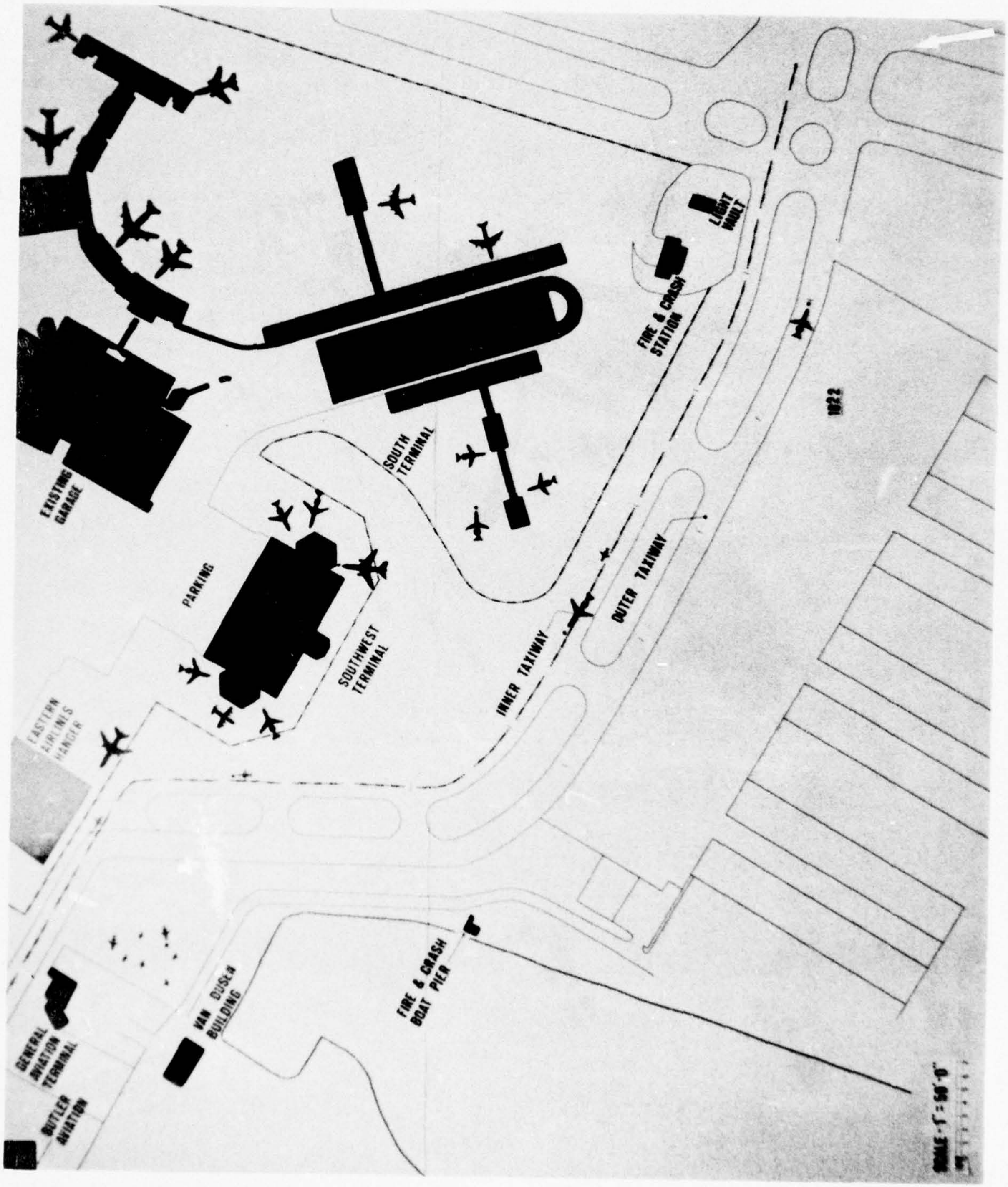


Figure III-18

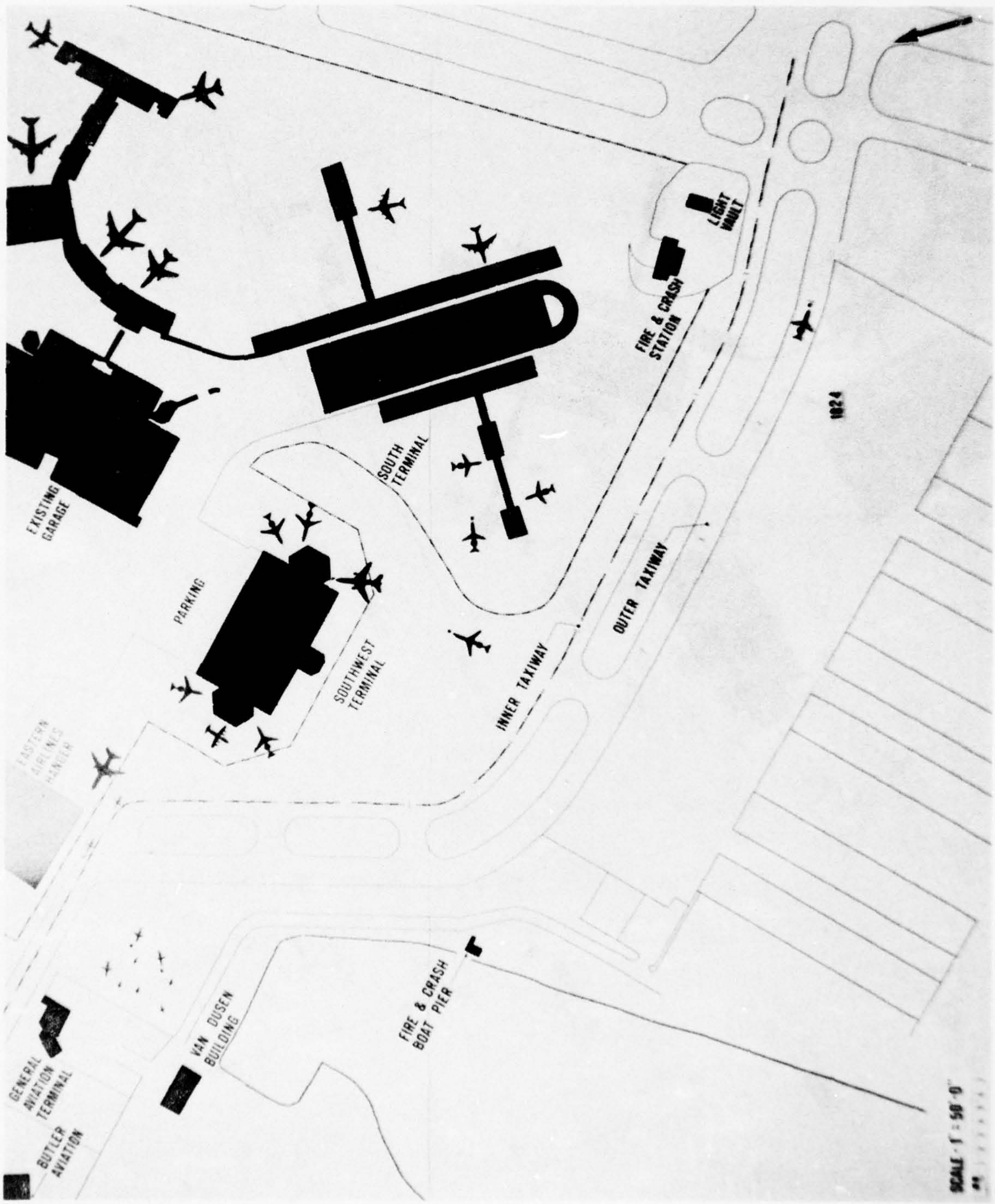


Figure III-19

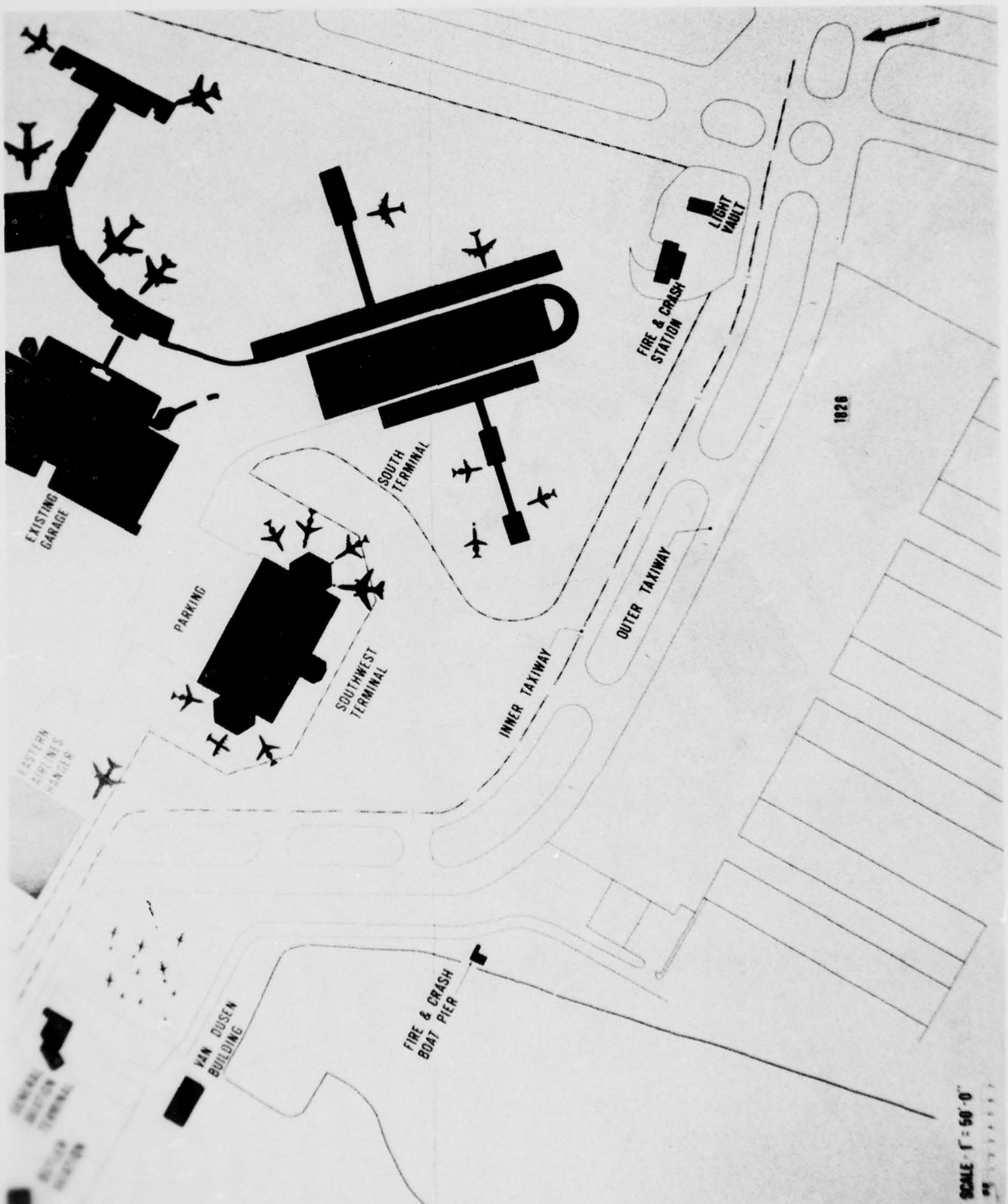


Figure III-20

Table III-17. Aircraft Returned to Gate After Pushout During 1976 - Boston

Date	Flight	Aircraft	Delay	Remarks
Jan. 7	181	314	#3 starter inoperative	Pushout
Jan. 23	181	314	#3 engine won't start	
Feb. 22	881	166	#2 engine won't start	Canceled
Mar. 23	601	326	#2 engine won't start	
Mar. 28	393	148	#2 engine won't start	
Apr. 20	43	108	Hyd. quantity dropped on engine start	
May 1	944	305	Unable to start #2 engine after pushout	
May 25	944	314	Unable to start #3 engine after pushout	
June 1	5945	311	Unable to start #2 engine after pushout	
June 3	105	835	Unable to start #1 engine after pushout	
July 14	869	979	No cross tie check after engine start	
July 25	1021	926	Oil leak #2 engine after pushout	
Aug. 10	944	316	Unable to start #1 engine after pushout	
Aug. 19	145	827	Forward door slide out of case after pushout	
Aug. 30	1011	926	Engine start valve stayed open on engine start	
Sep. 8	505	140	#2 engine generator light came on after engine start	
Sep. 13	535	839	#2 engine starter failed	
Sep. 14	133	842	#3 engine unable to start	
Sep. 22	944	305	Unable to start #2 engine	
Oct. 14	149	938	On engine start R. generator would not pickup bus	
Nov. 15	383	173	On engine start #2 CSD ejector valve CB popped	
Nov. 12	377	122	#2 no ignition	
Nov. 16	377	163	#2 no ignition	
Dec. 16	945	306	#2 oil quantity dropped to 3 qts. on engine start	
Dec. 19	945	331	#1 won't start, #2 stagnates	
Dec. 21	517	161	#3 won't start	
Dec. 21	535	852	#2 engine no ignition	Canceled--Mechanical Problem
Dec. 22	1101	918	After engine start #1 generator relay chatter	
Dec. 31	605	120	#2 engine N_1 tach inop. on engine start	

(Source: EAL)

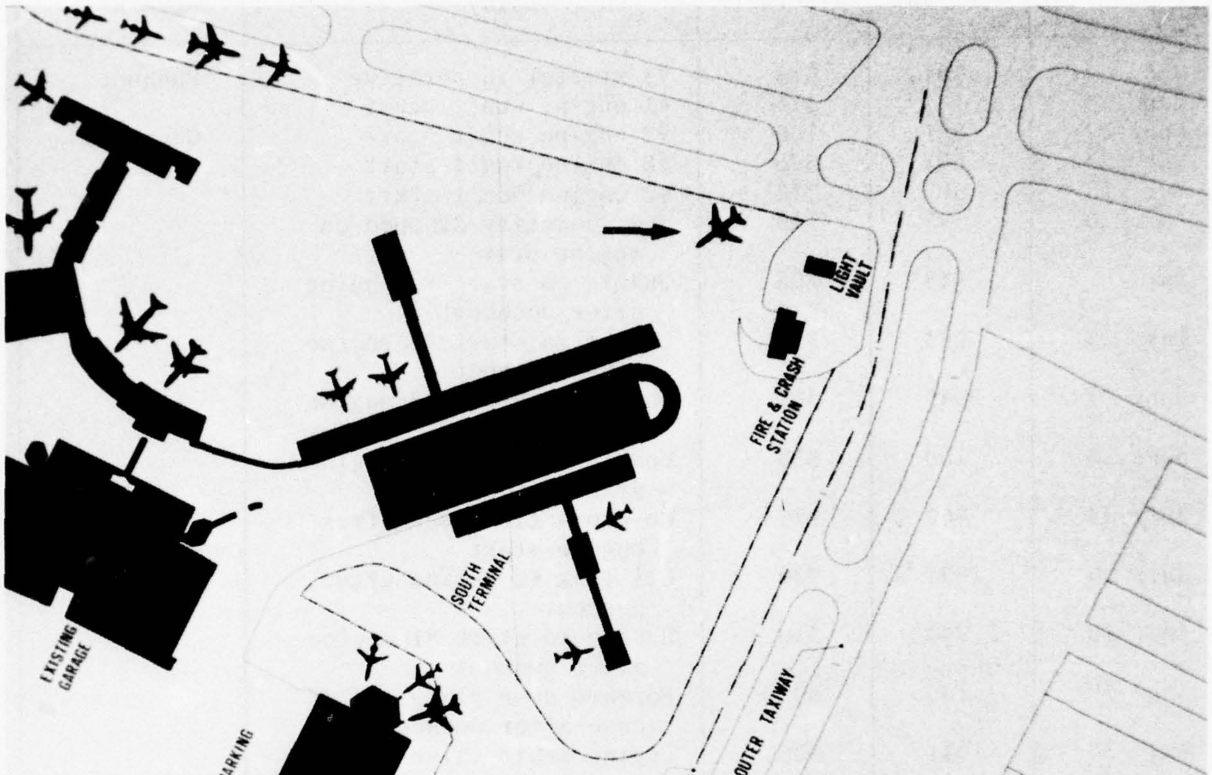


Figure III-21

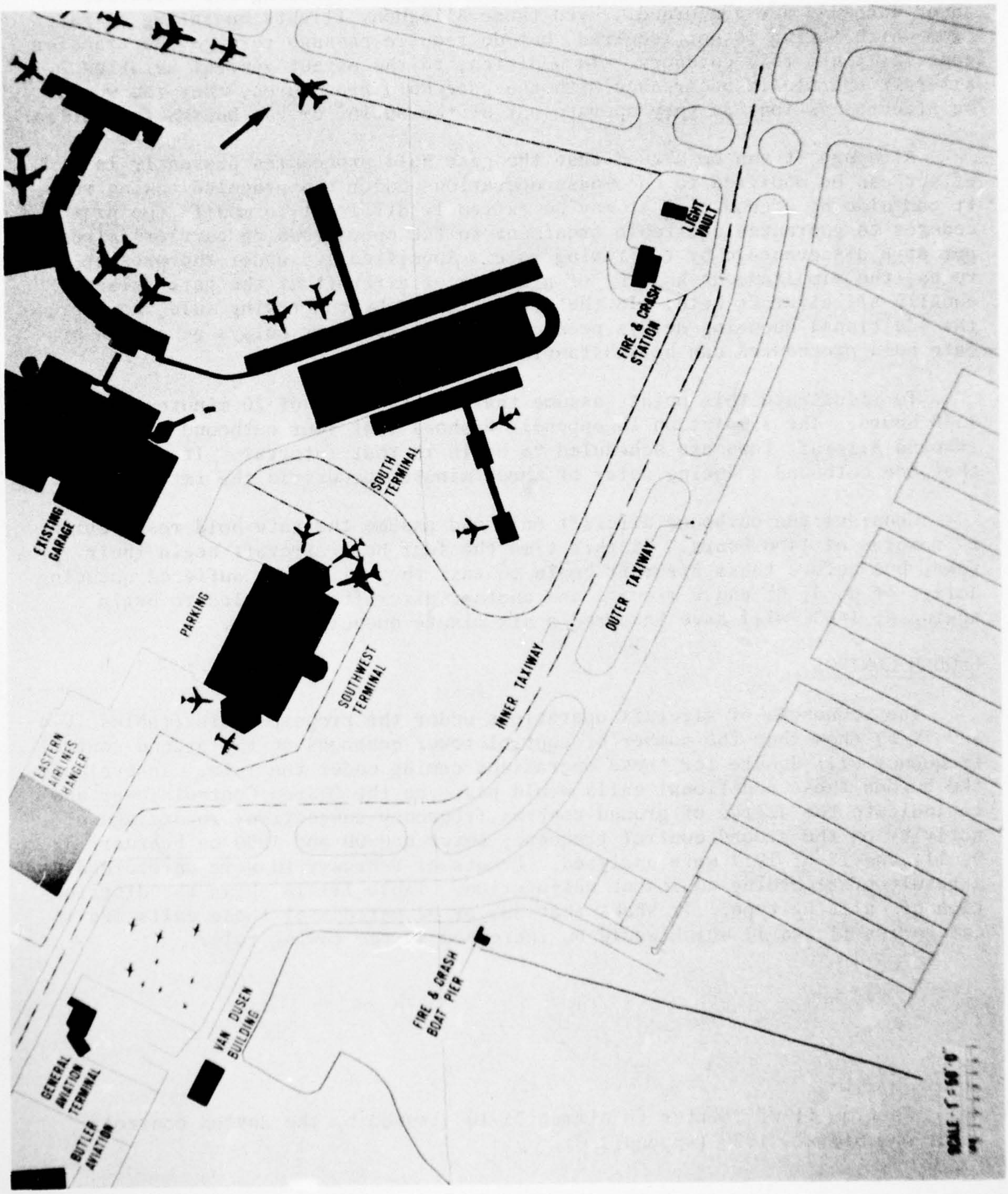


Figure III-22

on the community surrounding the airport. Review of the gate hold procedures[1] themselves leads to the conclusion that they would be placed in substantial jeopardy as far as aircraft being towed outbound or crossing the "transfer zone" outbound are concerned. Even those Allegheny flights operating at gates from which towing is not required, but do require passage through the transfer zone fall into this category. In addition, to the extent general aviation aircraft operate in accordance with the gate hold procedures, they too would be affected as long as they operate out of the Butler or Van Duesen facilities.

Although it can be argued that the gate hold procedures presently in effect can be modified to encompass operations under the proposed towing rule, it can also be argued that it may be extremely difficult to modify the procedures to guarantee equitable treatment to the operations of carriers already put at a disadvantage by the towing rule. Specifically, under the present rules, the simultaneous holding of a number of aircraft at the gate delays equally all aircraft held. In the area affected by the towing rule, however, the additional queueing delays produced by the departure delays generated by gate hold procedures can be substantial.

To illustrate this point, assume that a gate delay of 20 minutes began at 1340 hours. The simulation in appendix F shows that four outbound and four inbound aircraft tows are scheduled to begin in that interval. It also shows that one outbound queueing delay of three minutes occurs in the interval.

Consider the outbound aircraft only and assume the gate hold restriction is removed at 1400 hours. At this time the four held aircraft begin their tows, but before these aircraft begin to taxi they will have suffered queueing delays of 0, 3, 6, and 9 minutes and another aircraft, scheduled to begin towing at 1405, will have incurred a six minute queueing delay.

GROUND CONTROL

The sequences of aircraft operations under the proposed rule (tables IV-4 and IV-5) show that the number of control tower contacts on the ground control frequency will double for those operations coming under the rule. To evaluate the burden these additional calls would place on the Boston Control Tower and to indicate the degree of ground control frequency congestion, recordings of activity on the ground control frequency between 0900 and 1000 on February 8, 9, 11, and 12 of 1977 were analyzed. Events of February 10 were unrecorded as a result of recording equipment malfunction. Table III-18 shows the distribution of calls by type. It shows that 395 or 62 percent of these calls are in categories (T and I) which would be increased by the towing rule.

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[1]Section II of "Letter to Airmen 75-10" issued by the Boston control tower on July 22, 1975 (appendix G).

Table III-18. Distribution of Ground Control Calls

Call Code	Feb. 8	Feb. 9	Feb. 11	Feb. 12	Total	Mean
T	31	30	30	30	121	30
I	93	70	55	56	274	68
P	18	19	16	14	67	17
TI	29	30	28	20	107	27
O	16	19	15	20	70	18
	187	168	144	140	639	160

T: Taxi request after push-back and taxi off gate.
I: Information or instruction.
P: Request for push-back.
TI: Taxi inbound.
O: Other

(Source: GRA)

Table III-19, obtained from the data of February 8, gives an estimate of the distribution of call time by call type.

Table III-19

Call Code	Freq.	Time Used (Seconds)	Mean Time per Call (seconds)
T	31	430	13.9
I	93	596	6.4
P	18	121	6.7
TI	29	298	10.3
O	16	146	9.1
	187	1,591	

(Source: GRA)

A comparison of the sequence of aircraft operations under the proposed rule (tables 7 and 8) and those currently followed (tables 5 and 6) show that at least two calls will be added for each operation taking place under the towing rule. Allegheny Airlines and General Aviation operations will require more calls inasmuch as they do not presently require push-back. One of the

additional calls will fall in the T category; the other (tractor clearance to enter or leave a taxiway for the service road) will be an I type call.

On an average day, approximately 50 aircraft operations take place at Boston Logan between 0900 and 1000 hours; 15 will come under the proposed rule. These operations will add approximately 20.3 seconds each to the total channel utilization, thereby increasing the mean utilization in 0900 to 1000 hours from 1,408 seconds to 1,713 or 22 percent.

BENEFITS

The principal benefits of the proposed rule, in addition to noise reduction in the Jeffries Point area, is aircraft fuel savings. Table III-20 shows the estimated fuel savings that would be realized under the fully implemented towing rule. These savings are substantially in excess of those estimated by Eastern (see appendix H).

Table III-20

Operator	A/C	Daily Tows	Taxi Time (min)	Total Taxi Time (min)	Fuel Consp. Per Oper. (gal/min)	Total Fuel Cons. (gal)
Eastern	DC9	60	2.34	140	5	700
	727	60	2.34	140	6*	840
	L1011	4	4.25	17	15	272
Allegheny	DC9/B11	44	1.77	78	5	390
General Aviation	Jet/Turbo	88	3.00	264	1	264
			Total Daily Fuel Consumption			2,466
			Fuel Cost per Gallon			$0.3410
			Total Daily Fuel Cost			$841
			Annual Fuel Cost			$307,000

*Under current operations, 727 aircraft power-in on two engines. Fuel rates are 7 gal/min outbound, 5 gal/min inbound.

(Source: GRA)

COSTS

The proposed rule would place a considerable cost burden on the affected operators. Eastern Airlines, Allegheny Airlines and the Fixed Base Operators (Butler and Van Dusen) would require additional tractors and related equipment,

increased staffing to maintain and operate this equipment, and additional tractor fuel. Also, flight crew costs would increase for Eastern and Allegheny and aircraft utilization would decrease.

Table III-21 shows the GRA estimated minimum number of tractors required to handle the schedule analyzed in appendix F under both the current operation and the proposed rule. It shows that 14 new tractors would be needed under full implementation (Eastern 5, Allegheny 3, GA 6).

Based on its towing study, Eastern also estimated that five additional tractors would be needed to handle operations under the fully implemented rule. The estimated, nonrecurring cost of providing these tractors and related support equipment is shown as $608,000 in appendix H, Eastern Airline's Estimates of Cost Impact of Proposed Towing Rule. Extrapolating this estimate to include the three tractors needed by Allegheny gives a total of approximately $972,800.

Eastern further estimated that it would incur the following additional necessary ground handling costs.

Personnel	
Towing	$1,033,159
Equipment Maintenance	58,365
Ramp Service	124,494
	$1,216,018
Equipment Depreciation	
Tractors	$ 76,666
Other	24,667
	$ 101,333
Material Expenses	$ 45,434
Total	$1,363,785

Extrapolating these estimates to include Allegheny's towing operation gives an estimated total of $2,182,000 as the additional recurring ground handling cost.

It is estimated that General Aviation operators will be charged approximately $50 per round trip tow by the fixed base operators. Table III-21 shows a daily mean of 44 GA round trip tows. At $50 per trip the annual cost to GA operators comes to approximately $800,000.

Table III-21 also shows that an additional 3,189 minutes of tractor fuel consumption will be logged daily by Eastern and Allegheny tractors. At a fuel consumption rate of 14 gal/hour and a cost of $0.3633 per gallon, the incremental cost of tractor fuel would be $98,000 per year.

Total annual recurring ground handling costs to Eastern, Allegheny, and the GA operation is thus $3,080,000.

The impact of the proposed rule on airline flight crew costs, in-flight service costs, and aircraft manning costs is complicated by the complexity of the labor agreements and pay determination formulas relating to these matters, as well as aircraft and crew scheduling procedures. Therefore, the contractor has chosen not to pursue this estimation in the limited time available. The estimates provided by Eastern Airlines in their towing study report are included, however, in appendix H, for interested readers.

In conclusion: Longer ground time decreases aircraft utilization and may require a carrier to add aircraft to its fleet to maintain schedules.

Table III-21. Tractor Operation Summary

Tractors	Current Operations		Proposed Operations	
	Opns	Minutes	Opns	Minutes
Eastern 1	40	280	40	802
2	17	119	29	589
3	5	36	20	427
4	--	--	18	395
5	--	--	10	196
6	--	--	8	177
7	--	--	2	59
8	--	--	1	21
Total	62	435	128	2,666
Allegheny 1	--	--	25	524
2	--	--	14	295
3	--	--	6	139
Total	0	0	45	958
General Aviation 1	--	--	34	688
2	--	--	25	490
3	--	--	13	284
4	--	--	9	196
5	--	--	6	130
6	--	--	1	19
Total	0	0	88	1,807

(Source: GRA)

SECTION IV

ECONOMIC EFFECTS OF THE MASSPORT TOWING REQUIREMENTS

INTRODUCTION

The economic implications of the proposed Massport towing requirements are substantial and they affect numerous parties, both institutional and personal. The objective of this section of the analysis is to identify all the economic issues growing out of the towing proposal, to associate those issues with the parties affected both directly and indirectly, and, wherever possible, to estimate the size and character of the economic burden or benefit resulting from the towing requirements.

Before beginning a detailed discussion of the economic implications of the Massport towing requirements it is appropriate to classify these implications in several ways. For example, many implications are shown most significantly through a requirement to invest capital to maintain a given capability or level of capacity (however measured) in a situation where towing is required as compared with the case where it is not. In general, the economic implications that are reflected in changed investment requirements and changed capital-output ratios can be expressed in monetary terms. The same is true for those economic implications reflected in a change in the expense or revenues streams (positive or negative) as a result of towing in accordance with the Massport requirement.

But attention must also be directed at economic implications that may not necessarily be manifest either through the capital investment required or in the stream of expenses or revenues generated; also, there are situations where the "tracking" of the financial resources tells only part of the story. It then becomes necessary to employ qualitative terms to identify and describe at least some of the economic implications of Massport's proposed towing rule. For example, the implications of such rules, as far as the viability of the national commercial air transportation system of the United States is concerned, are necessarily more qualitative than quantitative. Similarly, the implications and effects of the towing proposals upon the economies of Boston, of Massachusetts, and of New England are most appropriately expressed in terms that are largely qualitative. In the discussion that follows, the economic implications of Massport's towing proposals will progress from those areas where the implications are most readily expressed in quantitative and financial terms, to those where the discussion is increasingly qualitative in nature.

CAPITAL INVESTMENT REQUIREMENTS

The capital investment requirements facing various parties are likely to be changed as a result of the Massport towing proposals. Depending upon the reaction of each airline, these investment requirements may be increased or decreased. For example, should Eastern Airlines or Allegheny Airlines decide to provide Boston with precisely the same quantity and pattern of service with towing in effect as they would under other circumstances, they would clearly have to invest additional capital in order to accomplish this objective. The principal incremental investment in each case would be in the form of additional aircraft and tow tractors, as was discussed in detail in section III.

However, it is by no means certain that Eastern or Allegheny would choose to maintain their service -- in terms of either quantity or schedule pattern -- in the face of the Massport towing requirement. Either or both carriers have the option of reducing service at Boston and might choose to do so to an extent that capital investment requirements were minimal, unchanged, or even reduced. Again, these options will be discussed in greater detail below.

Either or both of the fixed-based operators (FBO's) serving Logan, Butler and Van Dusen, will be faced with the necessity of acquiring additional tow tractor equipment in order to meet anticipated general aviation requirements even if general aviation activity is materially reduced below historic levels as a result of the towing requirements. At present, only Butler has a towing capability; it is extremely limited and, in fact, is substantially committed through contractual arrangements to support certain air carrier operations in some periods.

Obviously Butler and/or Van Dusen can acquire additional towing capability and will have to do so in order to enable a large proportion of general aviation aircraft to operate at Logan.[1] Moreover, since a significant proportion of general aviation aircraft requiring tows are not equipped with auxiliary power units (APU's), the FBO providing towing service for outbound aircraft must also be in a position to provide starting power which also adds materially to the capital investment required of the FBO.[2] It has been estimated that the FBO's at Logan will require six additional tow tractors, at $80,000 each, to meet GA's towing needs after January 1, 1978.

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[1]It is recognized that a significant proportion of general aviation operations--principally third-level or commuter services conducted with turbo-prop and piston equipment--does not involve the general aviation terminal and hence does not require either towing or passage through the transfer zone. Still, under present arrangements virtually all corporate and private jet and turbo-prop aircraft will be subject to towing until and unless either the proposed towing regulations are modified, or the general aviation activity is relocated to a point approximately south of the fire station across both the inner and outer taxiways. The investment and other costs (such as the opportunity cost of the land required) associated with such a move have not been calculated, but they are certain to be considerable with their incidence indeterminate without further data and analysis.

[2]Whether as a result of the towing proposal or not, Massport has recently indicated its intention to move the general aviation activity, now conducted near Jeffries Point on the far southwest corner of the airport, to a location south of the outer taxiway and approximately opposite the fire station, not far from the approach end of runway 4, left. While such a move would likely reduce dramatically, if not eliminate, the towing problem for general aviation aircraft, substantial capital investment would be required; such investment presumably would be divided between the FBO's and Massport itself. (The extent to which such a move has been contemplated as a result of the towing proposals is unknown, and an estimate of the cost-effectiveness of the investment required is beyond the scope of this study. However, it is worth noting that the Master Plan for Logan International Airport allocates this prospective site for GA activity to other purposes; this raises a question concerning the opportunity cost of allocating such space to general aviation rather than to the purpose earlier called for.)

Massport's capital investment requirements associated directly with the towing proposal are difficult to discern. It is reasonable to assume, however, that the agency will require additional vehicles to operate on airport service roads to check compliance with the towing regulations. It is not possible at this stage to estimate this incremental investment with any accuracy.

EFFECTS ON EXPENSE STREAMS

A second category of financial resources to be influenced by the proposed towing requirements are the expense streams of various parties. Certainly, some of the air carriers serving Logan will have altered streams of expenses as a result of the towing requirements and their responses to them. For example, should either or both air carriers with aircraft that will have to be towed as a result of the noise reduction program elect to maintain airline service at pretowing levels, it would appear that to achieve this result their streams of expenses will be significantly greater than they were prior to the commencement of towing on a 24-hour per day basis on January 1, 1978.

For Eastern, maintenance of December 1976 scheduled service at Boston (including the shuttle) on a full-towing basis would mean that Eastern's Boston-related, out-of-pocket net expenses would increase approximately $1,220,000 per year. (This cost has been developed in section III). While there have been no direct calculations of the change in the expense stream facing Allegheny Airline (which would have to engage in towing from only half the gates in its new terminal facility), if Allegheny were to require tractor service to any significant degree, it would increase Allegheny's expenses dramatically. This is because at the present time Allegheny operates practically all its services on a power-in, power-out basis and does not require even push-back service for loaded aircraft.

Still, with respect to Allegheny, it is conceivable--given Allegheny's December 1976 schedule--that the airline could operate from its new facility in the south (Volpe) terminal without using any of the gates on the side of the finger from which towing is to be required. While this would reduce Allegheny's stream of expenses below what would otherwise be the case where, say, half their flights required inbound and outbound towing, it would not be without cost to Allegheny. Ramp congestion would be materially increased which, in turn, would inevitably run productivity down and costs up. (Other financial losses that would accrue to Allegheny will be considered below in the context of future services to be provided at Boston by this carrier.)

Even though only Eastern and Allegheny are directly affected by the Massport towing proposal's orientation towards noise reduction at Jeffries Point, it is clear that other carriers will be influenced indirectly and that this will, in some instances, be reflected in changed expense streams. For example, Northwest Airlines has two gate positions at the very end of the Volpe terminal, i.e., the southernmost gates. These gates are usually approached by Northwest aircraft taxiing along the inner or outer taxiways to the south of the fire station, turning right onto the ramp, proceeding in an approximately northeast direction passing the fire station to the north, and finally turning to the left into the gate position. If not altered, this procedure would inevitably involve Northwest aircraft taxiing through the transfer zone with possible attendant delays and added congestion; this would prove costly to Northwest not only in terms of fuel consumption and crew pay but also in terms

of reduced aircraft utilization. It may be possible to alter the taxi routes for inbound Northwest aircraft to avoid the transfer zone, but this is by no means clear because of the necessity to mate the jetways at Northwest's gates with the left side of the 727 aircraft being used. In the absence of a statement on the part of Northwest or Massport that a new taxi routing could be employed providing Northwest with the mobility required, it must be assumed that on some occasions Northwest flights will be delayed in their passage to (and possibly from) their gates as a result of having to traverse the transfer zone. These flights will have to take their turn in the queues which will form as aircraft transition from self-power to towing, or vice versa.

It may also turn out that other carriers will be adversely affected from a cost standpoint as a result of the towing proposals. If it so develops under frequently encountered, prevailing ambient wind conditions that L-1011 and/or Boeing 727 aircraft require a north orientation in order to start engines, then the taxiway segment between the inner and outer taxiways to the east of the fire station may have to be used as part of the transfer zone for such aircraft when outbound. Under this situation, not only would that taxiway section not be usable by aircraft coming out of the Volpe terminal (American, Northwest and National), but also it would add additional aircraft to the often heavy traffic on the inner taxiway northward from the intersection. This congestion must affect the three Volpe terminal carriers (besides Allegheny) and may even have spillover economic/financial impacts for carriers operating from facilities still further to the north.

It should be noted that the net expense streams of the various carriers could conceivably be affected beneficially as a result of the introduction of towing according to the Massport proposal. This can come about, however, if--and only if--one or more of the carriers affected directly by the towing proposals chooses to reduce its Boston service to the point where the net congestion on the airport is reduced. For instance, if Eastern Airlines were to reduce drastically, or even eliminate, its Boston service, its own stream of expenses at Boston would be reduced (even though its stream of income might be reduced even more) and this might beneficially affect the expense streams of other carriers on the airport which, afterall, under periods of peak loading, now compete with Eastern for space on the taxiways, runways, and the approach and departure paths leading to and from Logan. However, of course, the expense stream is but one side of the profit and loss equation for the air carriers individually and collectively.

REVENUE EFFECTS

From a revenue standpoint, the Massport towing proposals will have the following generally predictable results upon various air carriers: even if Eastern Airlines were to adopt the strategy of maintaining service at a pre-towing level, it is quite clear that Eastern's traffic would decline in both absolute and relative terms; as a consequence, Eastern's revenues would be reduced even while Eastern's expenses were increased. Eastern's revenue picture would change in this unfavorable way for several reasons. First, Eastern is in an intensely competitive situation over many of its key routes, with Delta being its principal competitor.

Table IV-1. Common Cities Served To and From Boston by Eastern and Delta

MIA	ATL	CLT
EWR	DCA	PHL
IAH	PBI	MCO
LGA	DFW	FLL
MSY	TPA	JAX
	BDL	MGM

(Source: Official Airline Guide, December 1, 1976)

Given the fact that passengers will usually choose the airline that offers the shortest scheduled time between two points (for nearly simultaneous departures), it is clear that through adherence to the towing requirements, Eastern's block-to-block times would be materially increased; this would be reflected in the schedules Eastern would be required to publish under the rules imposed by the Civil Aeronautics Board. While it is true that Eastern's vulnerability to traffic diversion is greatest where passengers have alternative air carrier routings available, it is also clear that Eastern's traffic would be most affected, other things being equal, on short rather than long outbound and inbound flights.

The shuttle is an excellent case in point. The addition of some ten minutes for Boston inbound and outbound shuttle flights amounts to an increase of about 15 percent to present shuttle block time between LaGuardia and Boston. This is a substantial increase, especially given the fact that passengers have numerous alternatives for flying between the two airports throughout much of the day.

Table IV-2 lists all Eastern flights to and from Boston for which there is another flight to or from the same city by another carrier within 15 minutes of Eastern's flight.

Table IV-2

Departure Time	Arrival Airport	Carrier	Flight No.	Type Equipment	
		Departures From Boston			
0700	LGA	EA	1000	D92	shuttle
0700	LGA	AA	577	727	
0800	LGA	EA	1010	D9S	shuttle
0800	LGA	AA	591	727	

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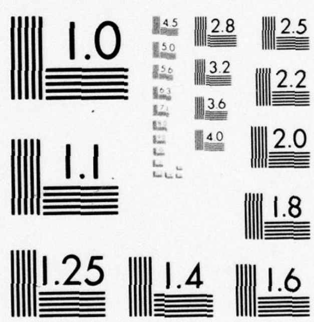

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table IV-2 - Continued

Departure Time	Arrival Airport	Carrier	Flight No.	Type Equipment	
0900	MIA	EA	41	72S	
0915	MIA	DL	207	72S	
0930	DCA	EA	869	D9S	
0940	DCA	AA	427	727	
1045	LGA	AA	85	72S	
1100	LGA	EA	1040	D9S	shuttle
1216	TPA	DL	453	727	
1227	TPA	EA	179	727	
1235	ATL	DL	227	72S	
1238	ATL	EA	533	D9S	
1500	DCA	EA	549	72S	
1510	DCA	AA	511	72S	
1552	DCA	AA	199	727	
1605	DCA	DL	315	72S	
1645	ATL	DL	419	72S	
1650	ATL	EA	129	72S	
1845	LGA	AA	271	727	
1900	LGA	EA	1120	D9S	shuttle
2000	LGA	EA	1130	D9S	shuttle
2008	LGA	DL	397	72S	
2200	FLL	DL	987	D8S	
2200	FLL	EA	429	727	
2200	MIA	EA	419	727	
2200	MIA	DL	481	72S	
		Arrivals at Boston			
0052	MIA	EA	418	727	
0052	MIA	DL	488	72S	
0743	LGA	EA	2160	D9S	shuttle
0748	LGA	AA	308	727	
0954	LGA	EA	2020	D9S	shuttle
0956	LGA	AA	124	72S	

Table IV-2 - Continued

Departure Time	Arrival Airport	Carrier	Flight No.	Type Equipment	
1050	LGA	AA	414	727	
1050	LGA	EA	2030	D9S	shuttle
1148	LGA	EA	2140	D9S	shuttle
1150	LGA	AA	254	72S	
1138	LGA	DL	366	72S	
1349	LGA	DL	2060	D9S	shuttle
1541	LGA	AA	530	727	
1549	LGA	EA	2080	D9S	shuttle
1644	DCA	AA	350	72S	
1654	DCA	EA	866	D9S	
1754	LGA	EA	2100	D9S	shuttle
1757	LGA	AA	488	727	
2052	LGA	EA	2130	D9S	shuttle
2107	LGA	AA	728	72S	
2210	DCA	AA	568	72S	
2212	DCA	EA	512	72S	
2317	PHL	UA	644	DC8	
2320	PHL	EA	608	727	

(Source: OAG North American Edition, December, 1976)

The information of table IV-2 is summarized in tables IV-3 and IV-4. Table IV-4 shows that 24% of all Eastern's flights serving Boston and 41% of the New York - Boston shuttle flights may be put at a competitive disadvantage. The latter figure is particularly important since the shuttle carries 43% of Eastern's passengers and generates 25% of Eastern's passenger revenues from the Boston market.[1]

[1]Eastern Airlines company records.

Table IV-3. Boston Flights Competitive* With Eastern Airlines

	Boston Departures			Boston Arrivals		
Carrier	Shuttle	Schedule	Total	Shuttle	Schedule	Total
AA	4	2	6	7	2	9
DL	1	7	8	1	1	2
UA	0	0	0	0	1	1
Total	5	9	14	8	4	12
EA Daily	16	38	54	16	38	54
Comp. Flights as % of EA Total	31	24	26	50	11	22

*Arrive/Depart within 15 minutes.

(Source: Table IV-2)

Table IV-4. Total Eastern Airlines Flights With Competition*

Carrier	Shuttle	Schedule	Total
AA	11	4	15
DL	2	8	10
UA	0	1	1
Total	13	13	26
EA Daily	32	76	108
Comp. Flights as % of EA Total	41	17	24

*Arrive/Depart within 15 minutes.

(Source: Table IV-2)

It is entirely likely that the Shuttle will suffer particularly large diversions of traffic once the full towing program is in effect. Again, it is worth pointing out that even if there were _no_ traffic losses on shuttle service --a wholly unrealistic assumption--the profitability of the shuttle for Eastern

would be greatly reduced as the expenses associated with the service would inevitably be substantially greater as a direct result of the requirement to tow all shuttle aircraft.

It should also be noted that the shuttle presents Eastern with a particular problem because of the variability in the number of shuttle sections dispatched at various times. One unique feature of the shuttle--a feature that is highly prized in the marketplace given the traffic the shuttle conveys each year--is that every passenger is accommodated on a shuttle flight no matter how many extra sections have to be flown. This places an exceptionally great burden on Eastern to maintain a capability to tow aircraft where the demand for towing can vary quite widely over relatively short periods of time--far more widely than would be the case without the shuttle operation.

As noted above, the longer the flight to or from Boston, the smaller proportionate increase in block-to-block time is caused by Massport's towing requirements. Also as noted, other things being equal, it would seem that the longer the flight, the less susceptible to diversion the traffic would be. But in many cases other things are not equal. The principal problem arises with respect to connecting traffic. It is instructive to consider Atlanta in this context. Both Eastern and Delta offer fairly heavy patterns of service between Boston and Atlanta. Through Atlanta, both Eastern and Delta serve substantial numbers of cities in the southeastern and southwestern United States. While some of these cities are served by aircraft that pass through Atlanta between Boston and other cities to the southeast, south, and southwest of Atlanta, a large proportion of passengers moving between such points and Boston are, in fact, required to change aircraft in Atlanta. This gives rise to the problem of connecting times.

The air transportation industry establishes at each airport minimum connecting times between flights. That is, tickets will not be written where connections are required unless there is sufficient time between two flights to enable passengers and their checked baggage to make the transfer. For Atlanta, minimum interline connecting times are 40 minutes between Eastern and Delta flights, and 30 minutes online between Eastern flights.[2] As a result of there being an enforced minimum connecting time, and especially given the nature of the Atlanta operation (where there are highly peaked activities several times a day to facilitate online and interline connections, to the extent that Eastern flights arrive or depart Atlanta at times different than would be the case in a no-towing scenario), the number of connecting flights available for Boston passengers at Atlanta would be changed, usually decreased. For example, if Eastern finds it prudent to have aircraft arrive at the gate in Boston at precisely the same time as in the pre-towing situation, this would imply that the aircraft would leave Atlanta about ten minutes earlier than would have been the case without towing at Logan. In this event, the flight loses 10 minutes "worth" of connections from Eastern, Delta and other air carriers at Atlanta. The number of flights involved varies with time of day and the specific case, but table IV-5 illustrates a typical situation based on the schedule as it existed in July 1976 and upon either of two conservative alternatives:

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[2]Official Airline Guide, North American Edition, July 1, 1976.

a. The Atlanta to Boston flight leaves Atlanta 8 minutes earlier than currently scheduled or,

b. The same flight leaves Atlanta as scheduled but arrives at Boston 8 minutes later than scheduled.[3]

Table IV-5. Eastern Passengers Lost if an ATL-BOS Flight Leaves Atlanta :08 Earlier, or Arrives Boston :08 Later.

	Per Day	Annual
Leaves Atlanta :08 Earlier		
Online Connections	0	0
Interline Connections	1.8	657
Total	1.8	657
Arrives Boston :08 Later		
Online Connections*	---	---
Interline Connections	0.3	110
Total	0.3	110

NOTE: Flight #534, ATL to BOS, depart 12:15 p.m., arrive 2:33 p.m.

Schedule Period: Spring/Summer 1976 (May through August).

*There are no on-line connections at Boston.

(Source: EAL Planning Department Computer Run based on Company Data)

Although the hypothesized shifts produce relatively minor traffic losses (table IV-5) there are some caveats which must be recognized. The traffic losses represent misconnected passengers under published minimum connecting times at Atlanta of 30 minutes on-line and 40 minutes interline. However, Eastern and competing carriers actually strive to schedule their Atlanta connecting complexes so as to allow for approximately 1 hour of connecting time, or about double the legal minimum. This allowance is necessary to maintain the smooth flow of connecting passengers and their bags between gates and

[3]Throughout most of the analysis, towing at Boston is assumed to require, on average, 10 additional (scheduled) minutes per flight. Early in the work program, several computer schedule analyses were carried out using what turned out to be an overly conservative 8 minute assumption. These data are cited since there was no opportunity to rerun the program with a 10-minute assumption.

between airlines. Anything less results in passenger inconvenience and some misconnected bags, as well as airport/airways congestion since Atlanta airport is tightly scheduled during peak periods. As a practical matter, therefore, if an Atlanta-Boston flight were to depart 8 minutes earlier, it would necessitate scheduling another Eastern flight to arrive at Atlanta 8 minutes earlier to assure full utilization of Atlanta facilities and full exploitation of Atlanta markets. Table IV-5 excludes any loss in connecting traffic at another city that might result and thus could understate the impact of the Massport towing proposal.

As noted, it is possible that Eastern would opt to have flights depart Atlanta at the same time as previously and thus arrive at the gate in Boston about 10 minutes later given the towing requirements. In this instance, the flights from which such an Eastern flight out of Atlanta might collect traffic would remain the same but Eastern (and its customers) would find themselves disadvantaged in two other ways. First, it might be that a passenger would choose a Delta flight leaving Atlanta at the same time recognizing that the Eastern trip would take somewhat longer given Eastern's towing requirements. Second, and often more important, the Eastern flight arriving in Boston later would lose connections onward from Boston that would otherwise have been available.

The carriers out of Boston that might be particularly hurt are the third-level carriers and Air New England, all of which derive a substantial proportion of their traffic involving Boston from connections which would be severely jeopardized by any substantial reduction in traffic whether triggered by a reduction in service or from towing. In addition, as will be discussed further below, certain international connections through Boston might become infeasible, if not "illegal", as a result of the lengthened scheduled times from towing requirements imposed upon Eastern and Allegheny at Boston. Table IV-6 illustrates potential connecting traffic effects associated with Eastern activities at Boston based on scheduled service in July 1976. It shows that during the month of July 1976, Eastern flight 538 carried 156 passengers from Newark and Raleigh-Durham to connecting airlines in Boston. The legal interline connecting time at Boston is 30 minutes. This means that if Eastern chooses to absorb at Boston the arrival delay created by the proposed towing rule, the new scheduled arrival time shown in the OAG would be 1750 hours. Connections to DL-230, DL-464, DL-500 and NE-528 would be eliminated and Eastern flight 538 would lose 52 passengers representing one-third of its connecting passengers.

When considering the effect of the towing requirements on available connections at Logan, it is of some importance to note that any delay in the gate arrival time of aircraft in the evening hours can result in a significant reduction in "legal" connections to Europe-bound flights from Boston. Table IV-7 indicates the connections that would have been eliminated in June 1976 had Eastern and Allegheny inbound flights been scheduled to arrive 10 minutes later than they did in fact; such connections would probably have included all Eastern's flights and about half of Allegheny's. Under such an assumption, connections with seven different trans-Atlantic flights which would otherwise have been "legal" would have become unavailable under the connecting time rules adopted by the carriers involved at Boston.[4]

[4]The same problems and issues obtained for inbound trans-Atlantic flights' connections with Eastern and Allegheny services from Boston.

TABLE IV-6

EASTERN ARRIVALS CONNECTING TO OTHER AIRLINES FROM

EA 538, JULY, 1976

76/07 CNX PT: BOS

INFLTNO	INORIG	INARVTIME	DEPT TIME	PSGRS	AIRLINE	DEST	FLT#	RPMS
0538	EWR	1742	1830	21	DL	PWM	0230	3,885
0538	RDU	1742	1830	2	DL	PWM	0230	1,224
0538	EWR	1742	1830	19	DL	BGR	0464	3,515
0538	RDU	1742	1830	1	DL	BGR	0464	612
0538	EWR	1742	1830	6	DL	BTV	0500	1,110
0538	RDU	1742	1830	1	DL	BTV	0500	612
0538	EWR	1742	1830	2	NE	LEB	0528	370
0538	EWR	1742	1835	2	QO	AUG	0018	370
0538	EWR	1742	1835	1	QO	BGR	0018	185
0538	RDU	1742	1835	1	QO	PQI	0018	612
0538	EWR	1742	1840	1	QO	BHB	0068	185
0538	EWR	1742	1845	2	DE	RKD	0046	370
0538	EWR	1742	1845	6	NE	ACK	0219	1,110
0538	RDU	1742	1845	2	NE	ACK	0219	1,224
0538	EWR	1742	1845	1	NE	EWB	0219	185
0538	DCA	1742	1845	1	NE	HYA	0219	399
0538	EWR	1742	1845	10	NE	HYA	0219	1,850
0538	RDU	1742	1845	2	NE	HYA	0219	1,224
0538	EWR	1742	1845	1	NE	MVY	0219	185
0538	EWR	1742	1855	4	NE	ACK	0247	740
0538	RDU	1742	1855	1	NE	ACK	0247	612
0538	EWR	1742	1855	2	NE	HYA	0247	370
0538	EWR	1742	1855	3	NE	MVY	0247	555
0538	RDU	1742	1855	3	NE	MVY	0247	1,836
0538	EWR	1742	1910	12	PT	PVC	0419	2,220
0538	RDU	1742	1930	1	QO	BHB	0028	612
0538	RDU	1742	2000	3	LH	FRA	0421	1,836
0538	EWR	1742	2000	2	ZM	LCI	0391	370
0538	EWR	1742	2015	1	NE	HYA	0275	185
0538	RDU	1742	2030	1	NE	WVL	0680	612
0538	RDU	1742	2045	2	PA	LHR	0054	1,224
0538	RDU	1742	2045	1	PA	LON	0054	612
0538		1742						38,468

Source: EAL Company Records

Table IV-7

DOMESTIC U.S.-TO-INTERCONTINENTAL FLIGHT CONNECTIONS ELIMINATED BY IMPLEMENTATION OF MASSPORT'S TOWING RULES

June, 1976

(Note: Minimum connecting time between flights at Boston is Sixty (60) minutes.*)

Arriving Flight No.	Original Arrival Time at Boston	Adjusted Arrival Time at Boston	Arriving From	Departing Flight Jeopardized	Departure Time	Destination(s)	Remarks
1700 EA Shuttle	1751	1801	LGA	AF054	1900	CDG	AF054 operated three times per week.
1700 EA Shuttle	1751	1801	LGA	AZ625	1900	MPX, FCO	AZ625 operated three times per week.
AL 25	1841	1851	PHL, ORF	TW910	1950	SMA, LIS, MAD, FCO, ATH	TW910 operated twice a week.
AL 186	1841	1851	PIT, TOL, DTW	TW910	1950	SMA, LIS, MAD, FCO, ATH	TW910 operated twice a week.
1800 EA Shuttle	1853	1903	LGA	LH421	2000	FRA	
1900 EA Shuttle	1954	2004	LGA	BA560	2100	LHR	
EA 578	2000	2010	ATL, PNS	BA560	2100	LHR	
AL 286	2048	2058	BUF	IN116	2150	SNN, DUB	IN116 operated five times a week.
EA 128	2136	2146	ATL, BHM	SR165	2245	ZRH	
AL 14	2136	2146	MDT, PIT, ORD	SR165	2245	ZRH	

*Official Airline Guide Worldwide Edition - June, 1976

Source: Official Airline Guide Worldwide Edition - June, 1976
Official Airline Guide North American Edition - June, 1976

GELLMAN RESEARCH ASSOC.

It is impossible to evaluate precisely what the financial and economic loss to the carriers (and to Boston) would be as a result of the reduction in legal connections between domestic and international flights at Boston. Suffice to say that the loss would be significant in at least three ways. First, to the extent that connects are less available or less convenient at Boston, both carriers involved in the traffic interchange will suffer lost revenues. Second, to the extent that traffic is diminished at Boston, concession revenues will be reduced and this is especially likely where international passengers are involved, given the airport-oriented expenditure patterns of such persons. Third, if connecting traffic is reduced at Boston in either direction, there is the possibility that one or more flights, or even carriers, might be withdrawn from the Boston-Europe market. This would surely represent a significant economic loss to Boston and to New England, if only because a significant factor considered by large corporations when establishing national or regional headquarters is the air transport service pattern available at such locations. For many such entities as well as for research-oriented academic and government institutions, the ready availability of service to Europe is of substantial importance.

It is also impossible to state with precision what the "threshold of pain" in terms of reduced traffic is for any given air carrier with respect to a given flight or its overall service at a station. However, especially where international carriers are concerned, it is thought that a relatively small swing in traffic can often cause the withdrawal of a flight or of a total service. Indeed, the latter seems to have happened recently when Iberia pulled out of the Boston-Spain market entirely.

In summary, relative to the expense and revenue streams of the air carriers serving Boston, the actual results will be determined only by the reactions of the various carriers to Massport's towing proposals, particularly as reflected in the level and pattern of service they choose to offer Boston with the towing requirments in force as contrasted with the situation without towing. It is possible to state categorically, however, that either expense or revenue streams for a number of carriers will be influenced and that, at least for Eastern and Allegheny, the net financial effects (i.e., revenues minus costs) must be detrimental. In fact, unless there is a substantial reduction of traffic on the part of either or both of these carriers, the profitability of serving Boston will certainly suffer materially for Eastern and/or Allegheny. In contrast, the profitability of serving Boston for Delta and perhaps other carriers may rise sharply but, as will be discussed below in the context of regulatory policy, this should not necessarily be considered an even trade off either for Boston or for the Airline industry.

As the the expense and revenue streams for Massport as operator of Logan International Airport, it should be clear that expenses will increase if only as a result of administering the towing regulations; assessing fines, and otherwise policing the operation. Even more important, however, is the situation that can be expected to face Massport on the revenue side. A major source of airport income relates to concessions. To the extent that passenger traffic is reduced in any significant degree, it can be anticipated that concession income at Logan will drop. Since there is the very real probability that the profit-maximizing strategy of Eastern and Allegheny will be to hold service to levels substantially below that which would otherwise obtain, it should also be

obvious that concession income would be reduced. But this is not all that Massport would suffer on the revenue side.

If Eastern and/or Allegheny reduced service to Boston below levels that would otherwise be offered, airport landing fees would have to be increased given the fact that landing fees are scaled to provide, in the aggregate, a certain quantum of funds that are needed to support the operating expenses and the debt obligations of Massport and of the parties that are jointly and severally liable on the debt underlying many of the airport improvements. It is certain that if airline activities are reduced at Logan, the fee per landing is going to have to be increased in order to make up for the shortfall in gross revenues associated primarily with the reduced airline activity but also as a result of possible reductions in concession income. This means that the level of landing fees charged by Massport to airlines, and perhaps even airport space rentals, will have to be increased; concession prices may also rise as Massport seeks to obtain as much revenue from these sources as possible to minimize the impact of landing fee shortfalls on the airlines individually and collectively. All this may occur while Massport incurs undetermined additional administrative costs directly related to policing its towing regulations.

Of course, one class of activities at the airport that can be affected as a result of Massport's increased expenses and possibly diminished revenues relates to the general aviation (GA) community. Massport may find it necessary to increase landing or other fees to general aviation aircraft which, if drastic enough, may substantially discourage GA activity at Logan, and perhaps even result in a decrease in gross revenues rather than the increase which higher fees were designed to accomplish under the circumstances.[5] While it is not possible without additional data to suggest what the elasticity of demand for general aviation services at Logan might be, it is at least a reasonable proposition that GA activities might be materially discouraged, at least until the GA terminal is moved so as to minimize or eliminate the delays and costs associated with towing.

It may be that Massport wishes to discourage GA activity at Logan. If so, the towing proposal may have a beneficial effect in Massport's view. However, if Massport does not have a conscious policy of discouraging general aviation activity at Logan, it would be wise for Massport to determine the nature of the demand for such services so that it does not inadvertently produce a result that is inconsonant with its overall plans and objectives.

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[5] It should be noted that any prospective landing fee increases are likely to be dwarfed by the increases in operating costs for GA aircraft that have to be towed at Boston/Logan. The principal factors leading to such operating cost increases include a towing charge levied by an FBO--estimated to be not less than $50 per round trip to and from the transfer zone--increased fuel consumption while awaiting entry into the transfer zone (or clearance from it), and decreased utilization of the aircraft due to extended ground times at Logan. These costs, more than increased landing fees, will serve to discourage certain GA activity at Logan and they grow directly out of the towing requirement.

AIR CARRIER SERVICE OPTIONS

As previously noted, air carriers affected directly and indirectly by the Massport towing proposals have the option of making adjustments in the quantity and patterns of service they provide to and from Boston. Presumably, they will adjust their short- and long-term reactions to Massport's requirements in such a way as to maximize the long-run profits (or minimize the long-run losses) they realize as a result of serving Boston. Many factors will influence the way each carrier reacts; therefore, determining the proper adjustments to make in the short- and long-runs is not a simple matter. It would seem, in general, that the air carriers principally affected by the towing requirements will pursue one of several general strategies in the short-run. They will pursue the same strategy or a different one in the long-run when they are able to make certain investment adjustments which, by definition, they cannot accomplish in the short-run.[6]

There are four basic reactions that Eastern and Allegheny might have to the Massport towing requirements in terms of level and pattern of service. First, it is conceivable that either or both carriers would choose to maintain the same level of service after towing is fully implemented as they did prior to the towing requirements. As noted previously, this would require every Eastern flight to be towed both inbound and outbound and would require approximately half of Allegheny's services to be towed if the gate assignments after towing were to remain the same as they were in December 1976. Consistent with this scenario, either or both carriers might also elect to expand their Boston services at the same rate and in the same way as was contemplated prior to the implementation of towing. For the sake of maintaining a conservative approach in the present analysis, however, future growth in traffic will be ignored in the remainder of this discussion and analysis.

A second rational scenario might be to reduce scheduled services to (and from) competitive points to the level that the remaining services attract sufficient traffic to provide at least a break-even financial result to the carrier. It is highly probable that for Eastern, at least, this would mean a substantial portion of its services at Boston would be curtailed for two reasons. First, it is likely that passengers would shift to Delta or other carriers because the scheduled and block-to-block times on the latter would be less than on Eastern. Second, regardless of the way Eastern adjusts its schedules, its customers will have less advantageous and probably fewer connection options for onward travel (or inbound travel) both at Boston and at other stations. Of course, it is not possible to state with precision to what extent either Eastern or Allegheny would reduce its service if it pursued this course, but it is clear that the menu of travel possibilities offered to and from Boston would be neither as varied nor as competitive as before.

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[6] In the economic short-run, among other things, a corporation maximizes profits within the limitations of its currently-held capital. In the long run, it may expand or reduce its capital in order to adjust to changes, or expected changes, in market conditions.

A third possible general strategy would be for either or both of the directly affected carriers to drop service completely to (and from) points where there is direct airline competition and to continue serving only those points where they are in a position to offer the only single-carrier service. Under this strategy, both Eastern and Allegheny would reduce dramatically their service at Boston. Table IV-8 indicates the cities which Eastern would no longer serve directly from Boston based upon its December 1976 schedule under this approach. The cities which Eastern would continue to serve under such a general strategy are shown in table IV-9. For Allegheny, the points served from Boston exclusively by that carrier are shown in table IV-10 while those points which it served in December, 1976, on a single-plane basis competitively with one or more other carriers are given in table IV-11. Obviously, under this approach Allegheny's service to Boston would be curtailed substantially although perhaps not as drastically as Eastern's.

Then there is a fourth and most drastic alternative: complete suspension of service at Boston. Certainly, it is difficult to see how either Eastern or Allegheny would be serving a rational profit maximization (or loss minimization) objective by eliminating service at Boston completely in the short-run. Even if this were to be the most prudent course in the economic long-run when, for example, their terminals and other buildings could be leased to other tenants, personnel could be laid off with minimum financial penalties to the company, etc., it is doubtful that either or both of the carriers could rationally eliminate Boston from their route networks. Still, this does remain a possibility and ought to be listed as such even though the probability of its happening is very low indeed.

As a practical matter, it would appear that Eastern Airlines' service to Boston would be somewhat curtailed in the face of the Massport towing requirements. Especially the Shuttle service would likely be limited if not withdrawn entirely, for it represents a market in which Eastern would appear to be most vulnerable of all. Moreover, based on conversations with Eastern executives and with published statements of Eastern personnel, it is also probable that the Shuttle is among the least profitable services that Eastern offers at Boston and that if Shuttle costs were to be materially increased and/or revenues cut as a result of the towing requirement, Eastern would find more profitable use for the capacity represented by the aircraft dedicated to the Boston Shuttle and that these aircraft would, in fact, be placed in other services, many of which could not be expected to touch Boston.[7]

For Allegheny, the likely reaction to the Massport towing requirements is to restrict severely, if not close off entirely, any increased service pattern offered to Boston. As previously noted, Allegheny could all but eliminate the requirement to tow by moving all flights to the one side of the pier the carrier occupies in the Volpe terminal where the gates require no towing. But this would mean that Allegheny could not expand its service in the Boston market without committing itself to the routine towing of loaded aircraft and it would be understandable if Allegheny were reluctant to do this. It is clear

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[7]As noted above in the discussion about air carrier and airport operations under a towing requirement, the Shuttle's variable extra-section policy poses special problems--both operational and economic.

TABLE IV-8

EAL COMPETITIVE SERVICE (AT BOSTON)

City	1976 Passengers
New York	1,530,141
Orlando	114,321
Miami	92,742
Atlanta	121,295
Houston	51,195
Tampa	50,134
Washington	129,833
West Palm Beach	38,287
New Orleans	34,650
Fort Lauderdale	36,465
Jacksonville	23,069
Louisville	9,498
Montgomery	3,879
Philadelphia	8,617
Dallas	1,131
Hartford	7,719
Providence	171
St. Thomas	5,324
Fort Myers	8,012
Charleston, S. C.	12,689
Montego Bay	4,261
Mexico City	3,164
Birmingham	6,099
Columbia, S. C.	7,747
Santo Domingo	2,520
St. Croix	1,946
Antigua	1,651
Evansville	2,927
Nassau	1,825
Chattanooga	2,676
Columbus, Ga.	2,325
Barbados	989
Freeport	1,614
Lexington	2,019
St. Louis	1,269
Macon	1,351
Port-of-Spain	493
Memphis	797
Martinique	374
Bermuda	774
Portland, Oregon	245
Acapulco	239
St. Lucia	272
Los Angeles	153
Seattle	137
Nashville	276
Baltimore	587
Guadeloupe	69
Montreal	152
Chicago	41
Omaha	6
Allentown	11
Indianapolis	5
Huntsville	1
Toronto	2
Buffalo	2
Roanoke	1
TOTAL	2,328,192

(Source: EAL Company Records)

Table IV-9. EAL Monopoly Service (At Boston)

City	Passengers
San Juan	89,531
Sarasota	24,119
Charlotte	36,258
Daytona Beach	22,030
San Antonio	11,861
Raleigh/Durham	32,037
Melbourne	11,238
Richmond	14,943
Greenville, S.C.	12,475
Pensacola	7,171
Mobile	6,588
Greensboro	10,841
Gainsville	5,479
St. Maarten	3,553
Tallahassee	4,841
Corpus Christi	2,009
Ponce, P.R.	57
Total	295,031

(Source: EAL Company Records)

Table IV-10. Allegheny Monopoly Service (At Boston)

Allentown
Albany, N.Y.
Wilkes Barre/Scranton
Binghamton
Buffalo
Elmira
New Haven
Islip
Harrisburg
Newport News
Rochester
Syracuse
Toledo

(Source: OAG, North American Edition, December 1976)

Table IV-11. Alegheny Competitive Service (At Boston)

Baltimore
Hartford
Nashville
Cleveland
Columbus, Ohio
Cincinnati
Dayton
Washington
Detroit
Indianapolis
Memphis
Minneapolis
Chicago
Philadelphia
Pittsburgh
Providence
Louisville
St. Louis
Toronto

(Source: OAG, North American Edition, December 1976)

that Allegheny planned to expand its Boston operations prior to the towing requirement since it invested in the capacity to do so by acquiring a larger number of gates than is now required. Whatever its options concerning these gates, Allegheny personnel have expressed themselves as reappraising the Boston situation before implementing expansion plans for Boston markets.

PASSENGER TIME COMMITMENTS AND VALUES

In assessing the economic impacts of the Massport towing requirements, it is important to point out that passengers electing to fly with Eastern or Allegheny under a towing scenario are committing themselves to a trip of a few minutes' longer duration than would be the case without towing. There are many parameters influencing the calculation of the value of a passenger's time. Even though there is no general agreement as to just what that value is, it is universally accepted that a passenger's time does have value and, to the extent that this is so, the travelling public that is subjected to a towing scenario, and having made a certain time commitment to accomplish a given trip, is deprived of certain value that would otherwise be derived from their time. If ten minutes extra per trip were required for all Eastern passengers and for one-half of the Allegheny passengers handled at Boston in 1975 both inbound and outbound, and using the most conservative figure of $12.50 per hour as the value of a passenger's time,[8] then the towing requirement on a 24-hour-per-day basis would have cost passengers $6,900,000 annually at 1975 traffic levels[9] based solely on the greater time each passenger would have committed to the trip.

REGULATORY AND OTHER PUBLIC POLICY IMPLICATIONS

In view of the preceding discussion and analysis, it is clear that imposition of the Massport towing requirements on a full-scale basis as is now proposed for January 1, 1978, would carry with it numerous profound implications for regulated air carriers and would impinge upon public policy in a number of ways.

In 1938 Congress established the Civil Aeronautics Board with the explicit mandate given to that agency not only to promote transport aviation in the United States (and between the United States and other countries) but also to promote and foster a system of air transportation which would serve the needs of the American community at large. The framers of the Act recognized full well that in many air transport markets competition is required to assure the

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[8]The basis for using $12.50 per hour as the average value of a passenger's time is a report by the Office of Aviation System Plans, FAA, entitled "Establishment Criteria for Category I Instrument Landing Systems," December, 1975 (ASP-75-1).

[9]In 1976, company records disclose that Eastern handled a total of 2,623,000 passengers at Boston; Allegheny's total was 1,380,000, though only about half would have been on towed flights. Also it is true that with towing neither Eastern nor Allegheny would likely have experienced as high a level of traffic in 1975 as they did. The economic and policy issues associated with traffic diversions (or decreases) as a direct result of towing are considered in the next section of this chapter.

relatively efficient use of resources devoted to air transportation and also to give the public requisite security in terms of the quality and quantity of service provided in those markets.

So it is that the air transportation system of the United States has emerged as second to none in the world. Reliance on competition by the Civil Aeronautics Board has been a particularly important element in fashioning the air transport system of the United States. Route awards have been hotly contested by various parties at interest, and the individual and collective route structures of the United States airlines have evolved as a result of something other than a haphazard process. Competitive relationships between carriers in general and on specific routes in particular are a result of the ebb and flow of many forces, but probably none has had so profound an influence as those related to inter-carrier competition.

Air carrier markets involving Boston are among the most important in the United States. For even the largest of U.S. airlines serving Boston, their economic performance on routes to and from "the Hub" is of no small importance. Eastern and Allegheny are no exception, with Eastern being particularly concerned about Boston markets given the long-haul nature of much of the traffic Eastern moves in and out of Boston as well as the important role the Boston Shuttle plays in generating base revenues for the carrier at Boston. In an unusually large proportion of the markets served by Eastern out of Boston it is in competition with one or more other carriers. Certainly the most dramatic competition for Eastern is that with Delta Air Lines, especially since the latter acquired Northeast some years ago. As earlier noted, the competition between Delta and Eastern is fierce between such points as Boston and Atlanta as well as on routes between Boston and Florida and other points in the southeast and southwest.

It happens that Delta is one of the most financially successful carriers in the airline industry--in the United States or anywhere. In contrast, Eastern has not been a consistent stellar performer where earnings are concerned. It is therefore especially important to note that one of the inevitable effects of the Massport towing requirements would be to put Delta (and other air carriers) in both an absolute and relatively better competitive position than Eastern after the towing program is fully operational. Eastern's profits would be eroded and Delta's (and perhaps other's) materially enhanced as a result of inevitable traffic diversions following introduction of the full towing requirements. It would seem that a program having this sort of effect--even if the disparities in financial performance between the two principal competitors were not as they are--would have substantial interest for the CAB and for those responsible for monitoring the performance of regulated industries as well--such as the Congress and the national Administration.

Much the same can be said concerning the Allegheny Airlines situation under a towing requirement at Boston with one additional twist. Allegheny is one of a class of "local service" air carriers which were created after World War II and which remain more or less subsidized right up through the present day. While these carriers, including Allegheny, generally operate in markets where they have less competition from other air carriers, as they have grown and developed they have moved into markets where their principal competition is in fact other air carriers. With respect to Boston, for example, a substantial portion of Allegheny's traffic is competitive with TWA and Delta. For

example, Allegheny is head-to-head with the former carrier in such markets as Pittsburgh and Indianapolis, while the latter is its most significant foil in the Boston-Philadelphia market, among others.

So it is that Allegheny can expect substantial traffic defections if its service becomes less attractive than it is at present, as will surely be the case if Allegheny is required to tow a substantial proportion of its operations while its competitors are not. The public policy implications are particularly strong for Allegheny given the substantial and continuing public investment in the local service and regional air carriers under the circumstances it does not seem likely that the CAB will long suffer a local entity's placing constraints on carriers such as Allegheny where the effect would be to undermine the profitability and perhaps boost the subsidy requirements for that carrier, not to mention establishing a precedent which might cast a shadow over a substantial portion of the entire airline industry.[10]

There are public policy implications related to carriers which do not compete with either Eastern or Allegheny but which are providers of complimentary rather than competitive services. Air New England is an excellent case in point. The CAB has recently certificated Air New England to fill New England's requirements for intraregional and feeder air service, much of which is provided by Air New England through Boston.[11] In the summer, Air New England, for example derives perhaps as much as two-thirds of its total traffic through connections with other air carriers and a substantial proportion of this traffic is exchanged at Boston.

It is difficult to state with precision what effect the towing requirements would have on Air New England's ability to exchange traffic with Eastern and Allegheny but the situation could not possibly benefit the regional carrier even if it did it minimal harm (because Air New England's originating traffic could make connections with other carriers, for example). In any case, there would be some dislocation with respect to Air New England and, to this extent, there would at least be a nuisance to that carrier and therefore to the entire New England region which it serves. It should be pointed out that anything that would increase Air New England's costs or decrease its revenues would put it in a position of requiring greater subsidy than would otherwise be the case and this, too, might make it more problematical as to whether Air New England could continue to operate over the long run.

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[10]It is not beyond the realm of possibility that one of the affected air carriers, the airline industry through its trade association, or the CAB itself might seek to test whether constraints such as the Massport towing proposals represent an "undue burden on interstate commerce" of a nature that the Constitution might prevent. Obviously, such a court test would be expensive and time-consuming and will probably be avoided if there is any way to do so. Still, it is worth pointing out that such a test is possible and that it might be a rational step for one or more of the above parties to take.

[11]It is interesting to note in passing that Boston is known as the "Hub" in New England and this is related importantly to its role as a connection point for transportation services both within the region and between the region and other parts of the country and the world.

Another public policy issue relates to the Eastern Air Shuttle. This is a unique service not matched in any other market in the United States except the parallel Eastern Shuttle service operated between New York's LaGuardia and Washington's National airports. Eastern undertook the Shuttle at substantial financial risk to itself and the great and generally growing patronage is dramatic testimony to the extent to which Eastern has touched a responsive chord on the demand side of the air transportation equation.

The implications of introducing operating constraints which handicap a carrier in providing services of the character of the Shuttle substantially transcend the Boston-New York market. The issue will certainly be seen as reflecting the extent to which the Federal Government of the United States will permit local or regional authorities to impose restrictions upon innovative air transportation services such that they become unattractive to provide. Once more, this encompasses the CAB's area of interest and responsibility but it goes far beyond when one views air transportation as being merely one of the public service industries that are perforce subjected to substantial federal regulation and promotion.

The extent to which the Massport towing requirements imposed upon Eastern and Allegheny might affect postal service to and from Boston and New England remains to be determined. Certainly, however, the towing requirements as related to general aviation must influence the attractiveness of Logan airport as a stop or terminus in the national system of check transport and clearing operations that has grown and proved so profitable for the banking community in the past decade or so. Specific implications in these areas need to be further explored and assessed.

One interesting public policy implication of the Massport towing proposals which will not be considered in the present study relates to the equity aspects of the situation. Consider the position of Eastern and Allegheny in this regard: Each has very substantial "plant and equipment" investments situated at precise locations dictated by Massport, the proprietor of Logan Airport. In Eastern's case, the terminal location was selected quite a few years ago but the investment remains very large. Moreover, the replacement cost for this facility at another site on Logan Airport would unquestionably be several times the present investment, even if suitable space on the airport could be found.

Allegheny's situation in this regard is even more anomalous. Allegheny recently committed itself to making or supporting a substantial investment in a building which is so new that it is not yet fully operational. When Allegheny agreed to base its operations at the Volpe terminal, it certainly had no idea that it would likely be required to tow a substantial proportion of its flights to and from the transfer zone if it were to make full use of its investment and that, even then, there would be added costs which would reduce the financial attractiveness of some of its services.

ECONOMIC IMPACTS ON BOSTON, ON MASSACHUSETTS, AND ON NEW ENGLAND

There are both direct and indirect employment implications of the Massport towing requirements and they will likely differ in the short and long runs. The direct implications, i.e., those related to employment on Logan airport, are largely, but not completely, determined by the reaction of various air

carriers to the Massport towing requirements. For example, if Eastern and/or Allegheny elect to maintain previous levels and patterns of service at Boston, they will have to employ additional personnel in a number of categories. To this extent, employment at (or based upon) Logan will rise. Moreover, it is likely that Massport itself will have to add clerical and supervisory personnel to monitor the towing program and to assure compliance, levy fines, etc.

It is questionable, however, whether either Massport or a carrier's incremental employment derived from the requirement to tow aircraft can be deemed "beneficial," all things considered. Taking the case specifically of Eastern Air Lines, this carrier has estimated that it would require 103 additional personnel to maintain December 1976 levels of service under the full towing requirements. (See appendix H.) Such additional employment at Logan and in Boston might be generally desirable in some instances but since the countervailing effect under the present circumstances would be to raise the costs of Eastern (and to reduce the profitability inherent in Eastern's serving Boston), there has to be a question as to whether, on balance, any such employment gain would be long-term or whether, in fact, employment would not be maximized for Eastern (and other carriers) if they were able to provide service at the lowest possible cost and the highest possible profit realization for themselves so as to encourage service expansion leading inevitably to greater and more stable long-run employment. It seems entirely reasonable that the substantially increased employment requirements (i.e., reduced labor productivity) attendant to the introduction of towing would have the effect of discouraging Eastern and/or Allegheny from serving the Boston market; thus, in turn, might well lead to a long-term reduction of employment at Logan and a concomitant reduction of general economic activity in the Boston area.

With respect to employment, Massport[12] has estimated the wage multiplier to be 1.775 and the employment multiplier to be 1.875, based on a study of the Boston Standard Metropolitan Statistical Area (SMSA) by Stevens.[13] Stevens himself, in a recent telephone conversation, cited multipliers of 1.74 and 1.95, respectively, for the entire five counties (Essex, Middlesex, Norfolk, Plymouth, and Suffolk) which are wholly or partly included in the SMSA.[14] Massport's estimates are for airport jobs and the latter Stevens estimates are for jobs in the entire area. Since Massport holds that jobs with higher wages imply a greater employment multiplier and a smaller wage multiplier, the two sets of estimates are consistent only if average airport wages are less than average wages in the area under consideration. In any event, the multipliers

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[12]Massachusetts Port Authority Staff, The Effects of Limiting Night Flights at Logan Airport (Boston: Massachusetts Port Authority, August 1976).

[13]Benjamin H. Stevens, The Boston Regional Economy. Background for the Evaluation of Curfew Impacts (Amherst: Regional Science Research Institute, July 1976).

[14]Benjamin H. Stevens, Mary Johnston, and Gerald Karaska, The Fore River Bridge Reconstruction Evaluation: Technical Report, Volume IV: Economic Impacts of the Quincy Shipyard (Boston: Commonwealth of Massachusetts Department of Public Works, March 1975).

are hardly so large as to overcome the anticipated long-run negative reaction of air carriers and others adversely affected by the towing requirements either directly or indirectly. In fact, since the multipliers work in both directions, any longer term adjustment which reduces direct employment at Logan below the level which would otherwise obtain will have a significant adverse leveraged effect in the community beyond the airport.

With respect to Massport employment, it should be pointed out that, once more, any employment gains are largely illusory since whatever drives Massport's expenses up makes it certain that the cost of doing business using Massport facilities will rise, thus making them less attractive in both an absolute and relative sense. Put another way, with increasing costs at Logan, airlines and concessionnaries alike will find it less attractive to do business at such facilities as their own unit costs rise. The airlines will be particularly hard hit, in all likelihood, as landing fees are raised to cover the airport's revenue shortfalls as was discussed previously.

The implications of the Massport towing requirements for industrial development and corporate headquarters location are potentially significant though they remain impossible to quantify with precision. But it is clear that there are many users of air transportation in the Boston and New England areas that view with concern any threat to airline service levels and patterns at Boston. The statements furnished in the context of the Logan curfew hearings by the Boston Chamber of Commerce (October 1976) are substantial testimony to this view.[15]

The economic effect of noise reductions in the neighborhoods adjacent to Logan can be separated into two parts: the impacts upon people and those upon property values. The influences upon property values are more tractable and are addressed first.

It is generally agreed that the area of impact is included in census tracts 512, 505, and 504. The total annual contract rents in these three tracts in the 1970 census were $507 thousand, $296 thousand, and $348 thousand, respectively.[16] Following Kain and Quigley,[17] the estimates of the total value of rental property are ten times this, or $5.07 million, $2.96 million, and $3.48 million, respectively. The average values of owner-occupied housing units were $10,500 for tract 512, not given for tract 505, and $9,500 for tract 504. Assuming that the average value in tract 505 was $10,000, the total values of owner-occupied housing in the three tracts in the 1970 census were $3.5 million, $12. million, and $2.1 million, respectively. According to the Massport staff, "property values recorded by the U.S. Census are

[15]Proceedings of Greater Boston Chamber of Commerce Regional Air Transport Conference on Logan Airport (held February 19, 1976).

[16]Bureau of the Census, 1970 Census of Housing, Block Statistics: Boston, Mass. Urbanized Area (Washington: Bureau of the Census HC(3)-108).

[17]John F. Kain and John M. Quigley, "Housing Market Discrimination, Home Ownership, and Savings Behavior," American Economic Review (June 1972).

typically about 30% undervalued."[18] Dividing the total values of owner-occupied housing by 0.7 yields \$5.0 million, \$1.7 million, and \$3.0 million, respectively. Adding these results to the total values of rental property yields total values for residential property in these three tracts in the 1970 census of \$10.1 million, \$4.7 million, and \$6.5 million, respectively.

Engle and Avault[19] have estimated residential property market value indices for each neighborhood planning district of Boston for every year during the period 1946 to 1972. The index for East Boston increased 20% from 1970 to 1972. Furthermore, the greatest average annual increase for any period ending in 1972 was 15 % for the period 1969 to 1972. Applying this 15% average annual increase[20] to the period 1972 to 1976 gives an index of 1.75 for 1976 relative to 1972, and the total increase for the period 1970 to 1976 is (1.75)(1.20) or 110%. This implies an average 1976 value of owner-occupied housing units of about \$30,000. However, it appears that Massport itself has lately acquired residential properties in Jeffries Point and has paid in the order of \$34,000 for such units.[21] Under the circumstances, it is prudent to increase the value of residential property in Jeffries Point by an additional 13%, bringing the totals in 1976 to \$24 million, \$11 million, and \$15 million, respectively, in census tracts 512, 505, and 504.

The FAA estimates that each unit reduction in a Noise Exposure Forecast (NEF) raises property values by two percent for NEF greater than 30.[22] Applying this estimate to areas where an NEF is less than 30 as well, the one-time gain in property values for each unit reduction in an NEF in the three census tracts would be \$480 thousand, \$220 thousand, and \$300 thousand, respectively.

Methodolgy for estimating the economic benefits of noise reduction directly with respect to population is all but nonexistent. However the FAA has used a figure of \$400 per year per individual living within an NEF 30 contour as a measure of "disbenefits."[23] The populations of the three census tracts in 1970 were 3,074; 1,668; and 2,056, respectively.[24] The population of Precincts 1, 2, and 3 of Ward 1 was approximately 8,000.[25] According to a State census, the population in 1975 was 8,170 in these three precincts. Thus the 1976 populations in census tracts 512, 505, and 504 can be assumed to be approximately 3,100; 1,700; and 2,100, respectively.

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[18]Massachusetts Port Authority Staff, Memorandum to the Advisory Committee on the Costs of Noise (July 1976).

[19]Robert F. Engle and John Avault, Residential Property Market Values in Boston (Boston: Boston Redevelopment Authority Research Department, 1973).

[20]It is interesting to speculate on the effect Logan Airport's presence has had upon the rate of increase in property values in East Boston.

[21]Telecon with East Boston (Little) City Hall official, Martin Coughlin, February 1977.

[22]FAA, FAR Part 36 Compliance Regulation, Final EIS, op cit.

[23]Ibid.

[24]Bureau of the Census, op cit.

[25]Ibid.

The FAA disbenefit estimate of $400 per year per person within an NEF 30 contour can be used only to establish an upper bound on the upper limit of the NEF reduction due to towing. If each of the three census tracts were within the NEF 30 contour without towing, and if towing meant that each tract would be outside the NEF 30 contour, then the annual reduction in "disbenefits" to the residents in census tracts 512, 505, and 504 would be $1.2 million, $0.7 million, and $0.8 million, respectively. But, as shown in the next section, neither supposition is true.

The results of noise measurement data recorded near the intersection of Sumner and Lamson Streets on January 21, 1977, lead to the conclusion that the impact of taxi noise levels on the community is limited to those areas in close proximity to the taxiway unless there are unfavorable wind conditions. In 200 minutes of recorded data on January 21, 1977, there were no perceptible taxi events at the measurement site. The extent to which taxi noise contributed to the ambient noise levels at this location is not quantifiable but it may be concluded that any such contribution would be small.

Since the measurement site was at the approximate center of census tract 512, it can be concluded that at least half of the tract is not impacted on at all by noise from taxi events when wind conditions are favorable. It may also be concluded that other census tracts in Jeffries Point would not be impacted upon at all. To allow, however, for an assumed contribution to ambient noise levels from taxi events and to allow for some periods of adverse wind conditions, it has been assumed for purposes of economic impacts that all of census tract 512 would be impacted to some degree.

Although taxi events are not normally included in NEF calculations, and while no NEF values were derived by TSC, the usual methodology utilized in determining the impact of airport noise on residential property values uses NEF as the community noise level measure. In order to utilize this methodology and the accompanying data base which has been generated, NEF has been assumed to be the measure of noise impact in determining property values in this study. The problem then becomes one of estimating NEF reductions due to towing. Since a reasonable conclusion, based on the TSC measurement results, in that taxi noise is not perceptible for at least half of census tract 512, a reasonable assumption is that, even if NEF calculations included taxi events, any reduction in NEF due to towing would be small. Therefore, an assumption that <u>all</u> of census tract 512 would benefit from a one NEF reduction is liberal.

While it is impossible to quantify with precision all the costs and savings which accrue to airport "users" as a result of the same towing program based upon available data, even without calculating the safety or accident costs associated with towing, the net measurable economic costs borne by just the air carriers directly affected and their passengers are many times the benefits for Jeffries Point both on an annualized and an investment basis.

SUMMARY

The economic implications of the Massport towing regulations are substantial and broad. By and large, the economic impacts are negative although there are some direct benefits such as those associated with net fuel savings

for the air carriers directly affected. Indirect benefits include the increase in value of residential property in Jeffries Point associated with the towing program. But the <u>net</u> economic impact is clearly negative and sizable. Indeed, with the exception of the property owners and residents of Jeffries Point, no single party affected either directly or indirectly by the towing requirement will enjoy a positive net economic benefit.

Table IV-12 provides a summary of the "direction" and incidence of the several most important economic impacts expected to follow any imposition of Massport's Logan towing requirement.

Table IV-12

SUMMARY OF ECONOMIC EFFECTS OF MASSPORT TOWING PROPOSAL

	CARRIERS-DIRECTLY AFFECTED (EA & AL)*	OTHER AIR CARRIERS	MASSPORT	FAA	GA AIRCRAFT OPERATORS	FBO'S	AIRLINE PASSENGER	CONCESSIONAIRES	JEFFRIES POINT INHABITANTS	COMMUNITY-AT-LARGE
<u>CAPITAL INVESTMENT</u>										
Aircraft	-									
Tow Vehicles	-					-				
Ramp Vehicles & Equipment	-	?	-			-				
Communications Gear	-		?	?	-	-				
<u>EXPENSES</u>										
Fuel - Aircraft	+	-			-					
Fuel - Tow & Ramp Vehicles	-	?	-			-				
Labor - Aircraft Operations	-	-								
Labor - Tow & Ramp Vehicles	-		-			-				
Labor - Ramp Service	-									
Maintenance - Aircraft	-	-			-					
Maintenance - Tow & Ramp Vehicles	-		-			-				
Insurance	-	?	?		-	-				
<u>EXTERNALITIES</u>										
Noise Pollution							?		+	?
Atmospheric Pollution							?		+	?
Passenger Trip Time							-			
Revenue Effects	-	+	?			?		?		?
Liability Exposure	-	?	?	-	-					

<u>Key</u>: + = Beneficial Economic Effect
- = Undesirable Economic Impact
? = Indeterminate Economic Effect
Blank = No Effect

*Assumes EA and AL will seek to maintain previous service levels and schedules after the towing regulations are in force.

SECTION V

ENVIRONMENTAL IMPLICATIONS OF AIRCRAFT TOWING OPERATIONS

The current analysis was undertaken as a result of regulations promulgated by Massport which prohibit the self-powered movement of certain aircraft in specific areas of Logan Airport (jet aircraft without an auxiliary power unit (APU) are exempt from the towing requirements only by the permission of the airport manager). The purpose of this analysis is to assess the environmental implications of this regulation. The major environmental impacts are related to noise and air quality. Socio-economic and land use considerations are addressed in other sections of the report.

NOISE IMPLICATIONS

The determination of the noise implications on nearby residential communities which will result from the implementation of this regulation is a difficult task. This is because the lack of reliable data relating to the problem precludes the development of definitive conclusions with high confidence levels. No towing tests or simulations have been conducted under conditions which would provide a rational basis for an impartial evaluation of the noise impacts of towing versus taxiing. Not only have there been no such data collected from Logan Airport operations, but further, there are no controlled towing-taxiing experiments in the literature the Massport Recitals, Facts, and Conclusions state that: "Aircraft taxiing noise is a significantly intrusive annoyance for the airport's neighbors who are located near apron, gate, and hangar areas. In these areas, taxiing aircraft generate noise substantially in excess of normal ambient levels." However, no justification is presented for this conclusion nor are "significantly" and "substantially" defined.

It is possible that simulated noise levels could be derived analytically; however, such an analysis is complicated by several considerations:

° Few, if any, data are available on tow tractor noise emissions under fully loaded conditions. Existing data on APU noise levels are not well quantified and were not collected under controlled conditions.

° The combined impact of tow tractor/APU noise levels on general airport ambient noise levels has not been identified.

° Jet aircraft without APU's may continue to operate in the restricted areas as well as some other aircraft.

° The duration of the combined tow tractor/APU noise is considerably longer than the engine noise from self-powered taxi movements.

ATLANTA AIRPORT STUDY

One study report does exist which provides the basis for some general conclusions concerning the relative noise of APUs and engines at idle. This study was conducted at the Atlanta airport in December 1973 and is documented in FAA Report No. FAA-RD-74-114 (August 1974), "Aircraft Taxiing Noise Measurement." The purpose of the noise study was to determine whether changes in noise levels resulted from shutting off a portion of the engines during

taxiing operations. In order to assess the impact on noise levels, measurements were recorded at terminal roof areas, taxiways, and engine run-up test areas. The most relevant measurements for the present study were those recorded on the roof of the Delta Airlines Terminal. There were over 1,100 readings recorded at this location, including 222 of aircraft standing with APU on and 54 of aircraft standing with engine on. Figure V-1 depicts the location of the monitoring station on the Delta Terminal roof. Table V-1 presents a summary of the Delta roof measurement classified by type of event. Readings were also taken on the "Y" roof. These readings are not as applicable as the Delta Terminal readings because 1) only 360 readings were taken, 2) there were no readings of aircraft standing with engine on, and 3) the "Y" roof measurement location was such that the gates were not as equally porportional around the receptors as were those on the Delta roof.

Table V-1. Mean and Standard Deviations for Delta Roof Observations

(30-Second Readings Sorted by Comments)

Comment	Number of Readings	Mean dBA	Standard Deviation
No Comment	179	80.8	4.2
No Planes Near	303	77.7	2.4
Standing, APU On	222	86.3	4.9
Standing, Engine On	54	90.8	6.4
Taxiing In	76	84.2	4.6
Taxiing Out	182	86.2	3.8
Distant Takeoff	105	83.2	3.3
TOTAL, All Comments	1120	82.9	5.5

The principal problems with the Delta roof measurements are that all readings were not precisely normalized for distance and most of the engine-on measurements were of DC-8 aircraft, the noisest of all six aircraft for which average pass-by taxi noise readings were established in the study. Further, no towing operations were conducted, so the noise of the APU could be somewhat less than the combined noise for an APU and a fully loaded tow tractor.

The study report notes that, "Taxi throttle setting for commercial jets is usually idle, which is 10 percent of the maximum sea level static thrust. As long as symmetric thrust is maintained, three- and four-engine aircraft can shut down one and two engines, respectively, and still taxi with the remaining engines at idle. Frequently a higher thrust setting is required to initiate the taxi." Thus, noise readings taken in the study of aircraft standing at a close distance with engines at idle can be assumed to be an approximation of noise generated from self-taxi operations, at least for a large portion of the taxi time.

The average of measurements taken of the aircraft standing with APU on was 86.3 dBA while the average of the aircraft standing with engine on was 90.8 dBA. The average distance of the standing aircraft was estimated to be 100 feet from the microphone. Thus the difference of the noise between the APUs and the engines was approximately 4.5 dBA. It was noted, however, that most of the engine-on readings were for the DC-8, the noisiest of the aircraft for which taxi noise level averages were developed (50 feet from taxiway). Taxiway noise levels by aircraft type as established in the Atlanta study are shown in table V-2. Analyzing these data, it appears that if an adjustment is made for the relative noisiness of the DC-8, the APU is little, if any, noisier than average engine noise under idle or taxi-thrust conditions.

Table V-2. Mean Taxiway Bypass Noise Levels Measured 50 Feet From Edge of Taxiway (All Engines On)

Aircraft Type	dBA
Douglas DC-9	98.8
Boeing 737	100.1
Boeing 727	96.6
Douglas DC-10	93.8
Douglas DC-8	102.5
Convair 880	99.8

It is interesting to compare the taxi-in and taxi-out mean dBA readings shown in table V-1 with the mean APU noise. Because the taxi readings are average dBA readings and are not normalized for distance, no clear-cut conclusion can be reached. However, it would appear that the difference between taxi noise and APU noise may be small.

One of the major results of the Atlanta Airport study also has relevance to the current study. It was found that measurements of taxiway passbys and stationary engine runups indicated that engine shutoff procedures resulted in the following noise reductions: The DC-8 on two engines--5 dBA reduction; the 727 with one engine shut off--2 dBA reduction; the DC-9 with one engine shut off on the side of noise measurement station--10 dBA reduction.

LOGAN AIRPORT MEASUREMENTS

In order to cope with the lack of data as described in the preceding pages, the FAA arranged to conduct limited noise measurements in the Jeffries Point area on February 23rd and 24th, 1977. The noise measurements were taken by the Transportation Systems Center (TSC) of Cambridge, Massachussetts, as prescribed by the FAA. TSC had previously taken noise measurements in both the Jeffries Point and Neptune Road area in order to establish ambient noise conditions and to gather event noise levels. All noise measurement data submitted by TSC to FAA is included as appendix I. For purposes of clarity, a brief discussion of noise measures is found in appendix J.

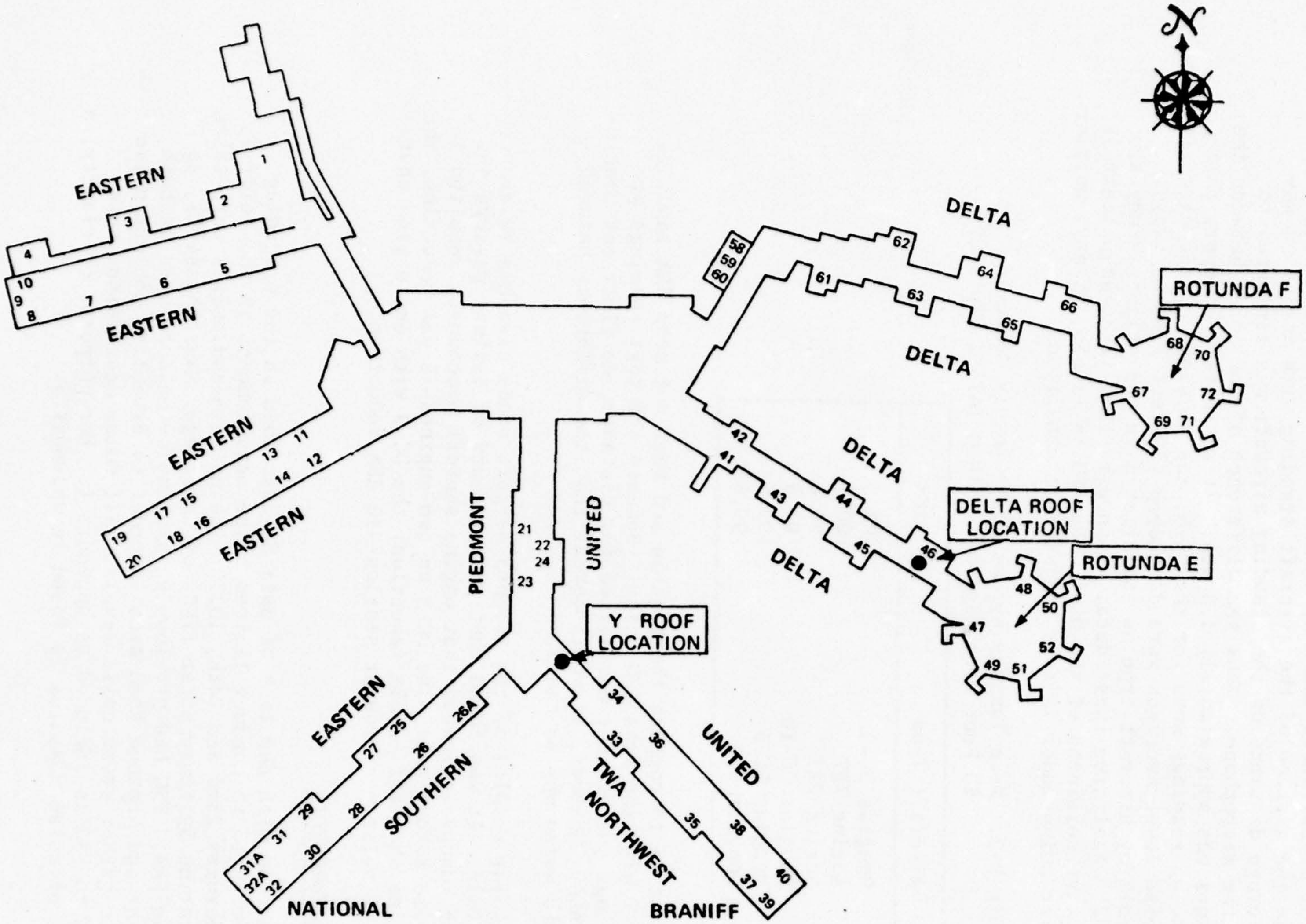

FIGURE V-1. ATLANTA AIRPORT TERMINAL BUILDING LAYOUT

Arrangements were made to take the February 23rd and 24th measurements near the extreme eastern end of Sumner Street. Measurements were taken from 7 a.m. until 9 a.m. During the evening, tests were taken from 8 p.m. on the 23rd until 1 a.m. on Thursday the 24th. Beginning at 7:10 a.m. on the 23rd, there was to be a "quiet period" for 10 minutes in which the only noise in the area covered by the towing regulation was to be the normal operation of APU's at the appropriate Eastern Airline gates and those Allegheny gates affected by the Massport towing regulations. Another test was planned for the morning in which a second quiet period was instituted. As planned, however, during this second period, a Lockheed 1011 conducted engine start and taxi operations.

During the evening test period, it was arranged to tow a Douglas DC-9, a Boeing 727, and a Lockheed 1011 in order to determine the extent to which tow tractor and APU noise exceeded ambient noise levels. It was arranged to start the engines on these aircraft in the vicinity of the fire station after they were towed to this location from the gates. The aircraft were fueled but had no ballast to simulate passenger and freight weights (see table III-7 for weights). It was estimated that the aircraft weights were about 10% below normal gross take-off weight. It was recognized that the level of confidence associated with measurements from only three tow tests is small. Tow-time measurements were needed, however, so it was decided to attempt to record each towing event noise level in the hope that the information would contribute to an understanding of the noise environment.

The results of the noise measurement tests conducted on February 23rd did not provide data which could lead to quantifiable results. There were some intrusions during the quiet period which was to have lasted from 7:10 a.m. to 7:20 a.m. One jet aircraft had engines running and did some taxiing during the period and one helicopter was flying in the area, thus diminishing the validity of a general conclusion to some degree. There was some reduction (appendix I) in most noise indices during the second 10-minute period (the quiet period). During the third 10-minute period, however, the noise indices were even lower, a situation which raises doubts about the usefulness of the test results since this third 10-minute period reflected normal airport operations plus the operation of those aircraft on hold during the quiet period. Thus, on the basis of these 10-minute samples, it is not possible to make a general conclusion concerning the contribution of taxiing aircraft to the ambient noise in the Jeffries Point area. TSC was able to identify several taxiing events during the two morning runs. (As explained in appendix I, the TSC "runs" consist of 50 minutes or five periods of 10 minutes each.) During the first 50 minutes, eight jet aircraft taxiing events with an arithmetic average of 71.7 maximum dBA occurred. Two events were less than 65 dBA (too close to ambient at the time to be included in the average) and one event was masked by another noisy event. There was one runup event with a maximum dBA of 71.8. Both taxi operations of propeller-type aircraft were masked by other noise events.

Thus, during the first 50-minute run, there were nine events above ambient and five which were either at or near ambient, or masked by other noise events. Reduced to simplified percentages, 64% of the taxi-runup events contributed to community noise levels at the measurement site while 36% did

not. Since at least a portion, and possibly all of the "runup" events were engine starts prior to taxiing, then the percentage of events contributing to an increase in ambient conditions will be overstated using this simplified allocation because of double counting.

The second test was conducted during the third segment (8:27 a.m. to 8:37 a.m.) of the second 50-minute run. Once again, all aircraft engines in the test area were shut down, but nominal APU operations continued. During the period, however, a pre-planned taxi operation of a Lockheed 1011 was conducted. The engines on the 1011 were started at approximately 8:32 a.m., the aircraft then taxied to the fire station and the engines were shut down. The engines were then restarted and the aircraft continued to taxi to the departure runway. TSC recorded the maximum start-up noise at the terminal at 70.3 dBA. The maximum taxi noise measured was 71.8 dBa; however, noise from other airport activities outside the test area were greater than the Lockheed 1011 taxi noise for a portion of the taxi operation. The engine startup at the fire station was not perceivable by personnel at the measurement site and could not be discerned in the TSC recorded data. As with the first "quiet" period, the average noise level during the 10-minute segment was lower than in the preceding 10-minute segment. Again, however, when normal operations (plus release of aircraft on hold) resumed in the subsequent segment, the indices were even lower.

During the second 50-minute run, several taxi-runup events were identifiable from the TSC measurement data. There were nine jet taxi events: seven of these had an average maximum dBA level of 75.2; one event was a low-level event of less than 65 dBA (too close to existing ambient levels to be included in the average); and one event was a low-level event which was masked by another noise event. There were two propeller aircraft taxi events with an average maximum of 74.2 dBA and one propeller runup which measured a maximum of 69 dBA. There was also one jet runup event which generated a maximum reading of 70.3 dBA.

Again, to reduce the second 50-minute event measurements to simplified percentages, 84.6% of the taxi runup events contributed to community noise levels at the measurement site, while 15.4% did not (if the possibility of double counting is not considered).

The results of the tow tests during the evening also do not permit the derivation of specific quantifiable conclusions. The primary problem encountered in the night tests was that the winds increased steadily from about 11 knots at the start of the measurements to about 17 knots at 11:30 p.m. Accompanying this atmospheric change was an increase in the general ambient noise level from the airport at the measurement site. Community activity noise in the area of the measurement site also increased. As a result, TSC was not able to discern any of the towing operations on their noise recordings. Massport and consultant representatives at the measurement site, who had small portable sound-level meters, were able to pick up maximum readings of about 67 or 67.5 dBA during the outbound towing of the Boeing 727, and attributed this noise to the APU on the 727. Similarly, a maximum noise level of about 65 dBA was recorded on the inbound 727 tow test but was not clearly attributable to the APU noise.

TSC was able to establish a number of taxi and runup noise event measures during the four 50-minute night runs. It appears that over this 200-minute recording period, there were at least 16 events which exceeded ambient noise levels at the recording site.

The impact of atmospheric conditions on the ambient and average noise levels can be determined if one compares nighttime runs one and three on February 23rd with nighttime runs one and two on January 27th. Both measurement days covered essentially the same time periods (between 9 p.m. and 12 midnight), with a maximum variance of only 5 minutes. Wind velocities were of comparable magnitudes on both days but had different directions. Both measurement days were weekdays and measurements were taken at the same site. The schedule of arrivals, departures, and ground operations should be roughly equivalent under these conditions, yet the L(99) measurements (which are an approximation of ambient conditions) calculated by TSC differ substantially. (See appendix I for a definition of L(99).) The L(99) measurements for the two runs on January 20 were 46.0 dBA and 48.6 dBA; yet the equivalent measures for February 23 were 60.7 dBA and 63.1 dBA. The average dBA readings for the two January 27 runs were 52.7 and 51.9; while the average dBA reading for February 23 were 67.8 and 67.1. The average maximum noise level for jet aircraft taxiing events during the first run on January 27 was approximately 60.7 dBA; the comparable figure for February 23 was 80.8 dBA. For the second run on January 27, the average maximum taxi noise for discernable jet aircraft was 60.9 dBA. The comparable figure for February 23 was 73.7 dBA.

A few comments concerning the measurements taken on Neptune Road and near the intersection of Sumner Street and Lamson Street are necessary (see figure V-2). The measurements recorded at Sumner and Lamson, taken when there was no wind, indicate that all taxi events were either masked by other noisy events or were too near ambient levels to calculate. On the other hand, all but one of the 50 jet aircraft departures were discernable. The average minimum departure noise for jet aircraft at this location ranged from 77.8 dBA to 80.4 dBA during the different runs, and the average maximum departure for the 11 discernable propeller departures ranged from 67.6 dBA to 71.2 dBA. If L(99) measurements are taken as an approximation of ambient conditions, the average ambient levels at this intersection varied around 46.5 dBA. The highest L(99) measure in any 10-minute segment was 52.1 dBA.

These data are perhaps the most significant of all those found in the TSC recorded data. Based on these four 50-minute runs, one may conclude that typical taxi noises are not perceptible for a significant portion of the Jeffries Point community, at least when weather and wind conditions are not unfavorable. There are undoubtedly several factors which influenced this result in addition to the wind variable. First there are buildings which attenuate airport sounds; second, community activities probably contribute to the sound level at this site; and last, the low-thrust, high-frequency sounds typically associated with taxi events attenuate more rapidly than do many other airport noises.

The Neptune Road measurements were taken on January 19 and 26. The measurement microphone was 40 feet from Neptune Road and 3 feet from the airport property fence. An analysis of the measurement data reveal the impact of aircraft departures on certain of the noise measurement indices from runway

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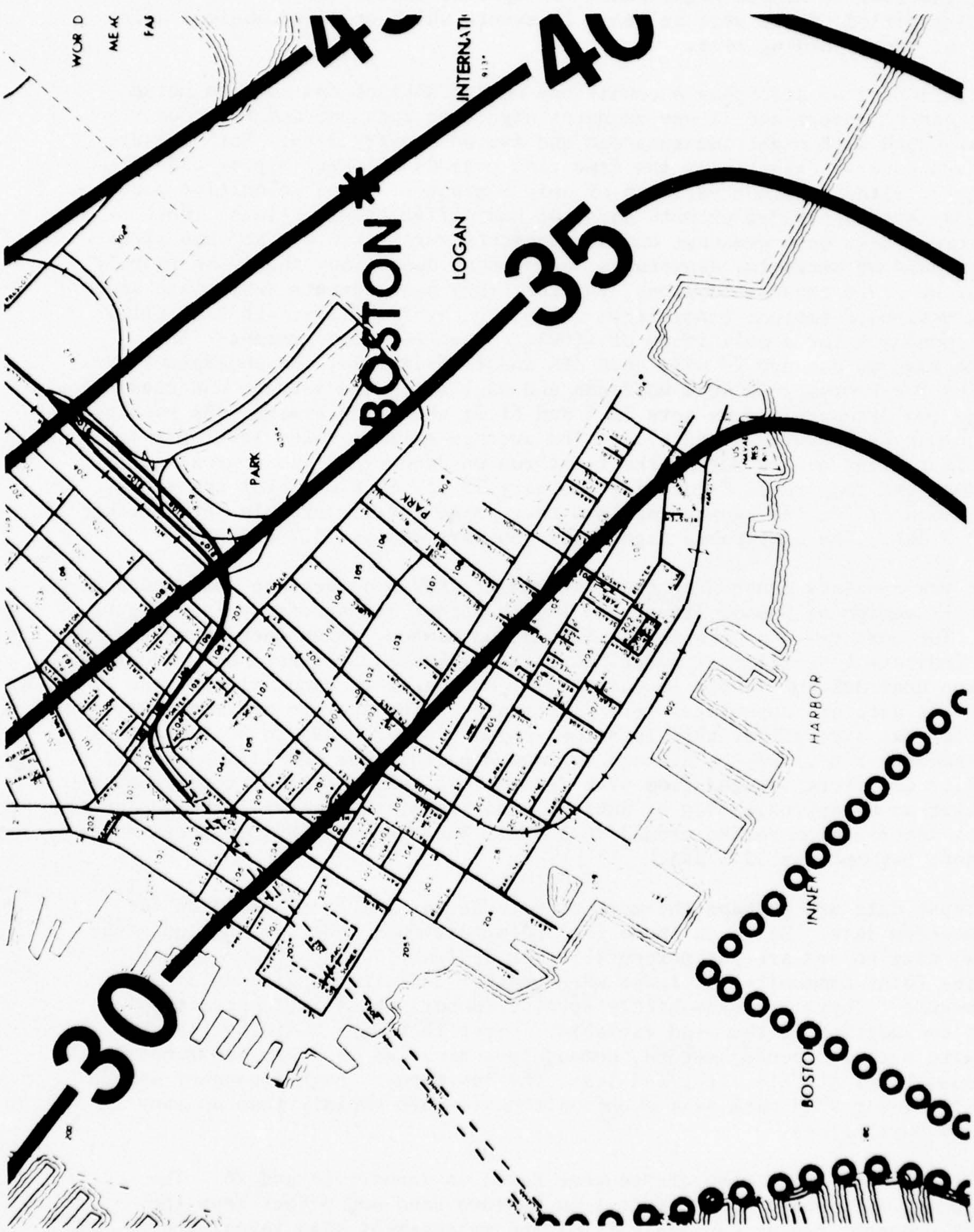


Figure V-2

33L. The L(99) and average dBA measures compare favorably with the Jeffries Point measurements; however, the impact of the 33L takeoffs are evident in most of the other indices.

Actually, only 13 taxi and runup events were identified in the seven 50-minute runs which were taken by TSC on January 19 and 26. Ten of these events occurred between 10 p.m. and 12 p.m. (seven events were during the last 50-minute run). During this same period, only three departure events were recorded for runway 33L. In analyzing the data, the impact of the taxi events on noise levels at the Neptune Road measurement station seems minimal. On the other hand, the data clearly reflects the impact of the departures.

AIR QUALITY IMPLICATIONS

Again, as with noise impacts, the problem in establishing the relative impacts of the towing versus self-taxi operations upon air quality rests in the lack of reliable emission data for APUs and tow tractors. On the other hand, emission factors for aircraft engines are well established. After discussions with staff members of the Environmental Protection Agency, Office of Air Quality Planning and Standards, the EPA publication "Airport Emission Inventory Methodology" (EPA-450/3-75-048, dated December 1974) was selected as the source document for tow tractor emissions data. Table V-3 lists the EPA emission factors which have been derived for two tractors and which were used in this study. It should be noted that these factors are based on heavy-duty, gasoline-powered vehicles. Nevertheless, these are the factors which are in general use by environmental analysts in the few studies which have been conducted on the aircraft towing concept.

Table V-3. Percent Emissions Contribution by Source
At O'Hare Airport - 1970

Source	CO	HC	NO_x	Particulate
Aircraft	69	79	86	96
Service vehicles	31	13	14	4
Fuel handling	0	8	0	0

A general conclusion of one of the several airport studies reported in the document "Aircraft Emission Inventory Methodology" concerns the relative contribution of air pollutant emissions of aircraft and ground service vehicles and is of general interest in the Logan Airport study. These values are set forth in table V-3. It was noted that about 90% of the carbon monoxide and hydrocarbon emissions shown in this table occur during the taxi/idle mode, whereas most of the nitrogen oxide emissions occur during aircraft takeoff and climb-out operations.

Thus, while aircraft do contribute to most air quality degradation at airports, service vehicles also have an impact, especially for the pollutant carbon monoxide.

In analyzing the impact of the Massport towing regulation on air quality, the aircraft emission factors depicted in table V-4were used in conjunction with the tow tractor emission factors depicted in table V-5.

Table V-4. Emission Factors for Taxi-Idle Mode

Engine and mode	Fuel rate		Carbon monoxide		Hydrocarbons		Nitrogen oxides (NO_x as NO_2)		Solid particulates	
	lb/hr	kg/hr	lb/hr	kg/hr	lb/hr	kg/hr	lb/hr	kg/hr	lb/hr	kg/hr
Pratt & Whitney JT-9D (Jumbo jet)	1,738	788	102.0	46.3	27.3	12.4	6.06	2.75	2.2	1.0
Pratt & Whitney JT-3D (Long range jet)	872	396	109.0	49.4	98.6	44.7	1.43	0.649	0.45	0.20
Pratt & Whitney JT-8D (Med. range jet)	959	435	33.4	15.2	6.99	3.71	2.91	1.32	0.36	0.16

Source: Compilation of Air Pollutant Emission Factors, AP-42, U.S. Environmental Protection Agency.

Table V-5. Tow Tractor Vehicle Emission Factors

Pollutant	Emission Factor (kg/hr)
CO	2.348
HC	0.525
NO_x	0.134
Particulates	0.004

(Source: "Airport Emission Inventory Methodology," EPA-450/3-75-048, EPA; December 1974)

Only the DC-9, 727, and BAC III aircraft utilized by Eastern and Allegheny airlines were considered in computing pollutant emission levels. Factors are not available for all general aviation aircraft and only two wide-body jets operate daily from the affected gates. Utilizing the air quality emission factors set forth in tables V-4 and V-5, the following emission reductions attributable to towing were found:

Table V-6

	Per event	Total airport
Carbon monoxide	53.3	13.3
Hydrocarbons	42.6	10.7
Nitrogen oxides	68.6	17.2
Particulates	86.0	21.5

Since only a fraction of the total operations would be involved in the towing operation, the reduction in emissions for the total airport are not as impressive as are those for a single event.

Based on the relative emission factors for gasoline-powered and diesel-powered trucks, it can be concluded that if emission factors were available for large, diesel-powered tow trucks, further reductions would be shown for CO and hydrocarbons, while there would be little, if any, reduction from current levels for NO_x.

CONCLUSIONS AND RECOMMENDATIONS

° Based on the only data available (the limited tests and measurements at Logan and the Atlanta Airport study), the difference in noise levels generated by towing and taxi operations cannot be quantified. The quiet period tests conducted at Logan Airport on February 23, 1977, resulted in contradictory test results. The quiet periods did result in noise level indices which were lower than in preceding periods. In both cases, however, the period immediately following the quiet period was less noisy than the quiet period itself. Since aircraft were holding during the quiet periods, it was expected that the resumption of normal operations would result in higher noise levels. Wind conditions affected the three towing tests in the evening; hence, it is not possible to draw quantifiable conclusions. Most taxi events were discernable throughout the day on February 23 at the measurement location near the yacht club however. Any conclusion drawn from this observation must be qualified by data collection on January 21, 1977, near the intersection of Sumner and Lamson Streets. On this day, there was no wind and none of the more than 29 taxi events observed were discernable.

It does appear that taxi events do contribute to noise levels in the community immediately adjacent to the Eastern Airlines/general aviation taxiway. More data is required to determine the extent of the impact of these events on the entire community. Further, to the extent that APU/tow tractor noise may prove to be perceptible, no consideration has yet been given to the effect on community noise of the longer duration required for towing.

The problem in assuming definitive conclusions from the Atlanta Airport study rests in the lack of precision in normalizing data and in the lack of rigorous controls during the study. The Atlanta study did result in an apparently valid conclusion that taxiing on only a portion of the engines did result in some noise reduction near the taxiway.

° More noise data, over an extended period of time, is required to determine the actual impact of implementation of the Massport towing regulation. Additional general airport noise monitoring measurements are required, including simulatenous recordings at different locations. Enough measurements are required so that the impact of weather and atmospheric conditions can be ascertained. More towing tests should be conducted under other atmospheric conditions so that some degree of confidence can be placed in any conclusions deduced from the data. It is possible that the considerable noise data which has been gathered by Massport could be of value in future analyses, provided it is in a form which would permit rapid assimilation and processing.

Thought should be given to the longer-term development of a model which would enable the simulation and determination of the contribution of ground operations noise levels. This would require the collection, normalization, and incorporation of certain noise events (taxi and perhaps towing) which are currently not generally considered in community impact prediction techniques, such as the Noise Exposure Forecasts (NEF).

° Better data on air quality emissions for tow tractors and APUs are required to properly address the implications of the proposed Massport regulations for air quality. If more reliable data were available, it might be worthwhile to simulate the dispersion of the emissions for typical seasonal periods.

SECTION VI

FINDINGS

SAFETY

Aircraft Towing in General

° Aircraft towing is a relatively hazardous activity. That is, when compared with the alternative of taxiing, by any standard towing is substantially less safe.

° Very little is known about the stresses to which the nose landing gears of either transport or general aviation aircraft are subjected in the course of towing; no current transport or general aviation aircraft appears to be fitted with a nose gear designed to take account of the loads such a component and associated structure would experience when exposed to substantial and repetitive towing under load.

° If aircraft are to be towed more often and/or at heavier weights than has been the case in the past, a great deal more needs to be known about the effects of such operations on aircraft nose landing gear and related structure.

° Communication and coordination between the tractor operator and the cockpit are unreliable and difficult. Technological solutions are available to solve the communications problem, but the coordination difficulties are of a different nature and will be present whenever a tug-aircraft combination is moved over any but the shortest distance, over any but the simplest route.

° Ambient environmental conditions have a substantial influence on the aircraft towing operation. Pavement conditions and relative direction and velocity of the wind cause particular problems and, under many conditions, significantly degrade safety even while they reduce the speed of towing.

° Hazards experienced in routine pushback operations are substantially less than those associated with extended aircraft towing. The primary reasons are: 1) the load imposed upon the nose gear in pushback is consistent with its design load which is generated in the landing regime; 2) command and control conflicts in pushback are minimal between the tug operator and the cockpit, given the nature of the operation; 3) pushback speeds are comparatively low; 4) pushbacks are usually accomplished employing wing-walkers; and 5) the duration of the pushback operation is typically short.

Towing at Logan Airport Under Massport's Proposal

° Logan towing operations would be characterized by substantial congestion to and from the transfer zone and in the zone itself through a substantial part of the day. This situation would be aggravated materially by the need to mix vehicles with dramatically different performance characteristics, such as tugs (either burdened or operating independently) and aircraft of various sizes (operating either under tow or taxiing).

° Especially in view of the congested nature of towing operations, the cycle stresses applied to the nose gears of towed aircraft will be high and the number of load cycles a landing gear experiences in a given towing operation will be great because of the nature of the proposed operation and the character of the route over which the aircrafts are to be towed.

° The command and control problem normally present in towing operations will be materially aggravated in the Logan Airport case due to the nature of the operation and the duration of each tow. The fact that the tractor operator and the cockpit crew have substantially different backgrounds, and the inherent conflict between the de facto control of the tractor operator and the de jure control of the captain can be expected to generate unsafe conditions under the proposed towing arrangement.

° No aircraft should be subjected to towing under load over the distances involved at Logan Airport without an operating auxiliary power unit (APU). Under the proposed Massport regulation, this would be at the discretion of the airport manager.

° Ambient environmental conditions frequently found at Logan Airport will further threaten the safety of the proposed towing operation. Especially dangerous would be those conditions arising from crosswinds of a significant velocity and of such a character as to make an aircraft under tow uncontrollable by the tug. Again, wet and slick operating surfaces, often experienced at Logan, will tend to undermine the operation's safety. Also, the duration of tow at times when the aircraft require de-icing on the ground prior to takeoff may neutralize the effects of the de-icing fluids applied at the terminal and cause the flight to abort or to continue on a less-safe basis than would otherwise have been the case.

° Given the location of the transfer zone and its relationship to certain runways, some types of aircraft may have insufficient time for their engines to reach "thermal stability" prior to receiving takeoff clearance.

° Given the geometric shape of the transfer zone which will frequently require that a series of aircraft be lined up nose-to-tail while starting engines, it is inevitable that airline and fixed-based operations (FBO) ground personnel will be subjected to substantially more jet blast than has been the case with civil aviation operations in the past. The full implications of this situation remain to be explored.

° In view of the nature of the operations being carried out in the transfer zone and the size of the transfer zone necessary to accommodate aircraft in peak periods, expeditious access of fire and crash vehicles to certain parts of the airport and adjacent areas may be jeopardized by the proposed towing regulations.

° Based upon airline experience and the nature of the proposed towing requirement as applied to inbound aircraft, passengers on air carrier aircraft will often tend to leave their seats prematurely, either at the time the aircraft stops in the transfer zone and shuts down its engines, or during the tow from the transfer zone to the gate. Such a hazard should be studied based upon airline experience.

° The increase in ground control frequency radio congestion during peak hours as a result of the proposed towing operations may jeopardize the ability of tower personnel to provide timely warning or instructions to aircraft (or vehicles) under the control of the ground controller.

° In view of the nature of the towing involved, it is prudent to require minimum standards of performance and of health for people operating tugs assigned to transfer zone duty. In addition, such people must be thoroughly familiar with radio procedures and capable of acting precisely and expeditiously in accordance with instructions given by a ground controller or the captain reacting to an actual or potential unsafe condition.

° Towing operations conducted under the proposed Massport regulations would be substantially more hazardous than aircraft towing in general has proved to be because of the increased times and distance involved.

OPERATIONS AND CAPACITY

Present Operations at Logan Airport

° By and large, present air carrier and general aviation operations conducted at Logan Airport are conventional when viewed against the background of experience and procedures at other large hub airports.

Operations Under the Massport Towing Proposals

° When and if the Massport towing proposals oriented to Jeffries Point become effective at Logan Airport, a significant proportion of airport operations will be conducted in a nonconventional manner. The airport operations directly affected would be limited to but two carriers (Eastern and Allegheny) and to general aviation aircraft, even though the operations of other carriers may also be influenced.

° Implementation of the Massport towing proposal will result in longer aircraft ground travel and trip times for all operations affected either directly or indirectly by the towing requirement. For Eastern and Allegheny flights, without taking account of transfer zone congestion which leads to queuing delays, trip times would be lengthened by a net amount ranging from 7 to 12 minutes for each flight operation.

° Queuing delays must be added for many flight operations conducted during peak traffic periods. Such delays would add materially to the time required for flights to move between the ramp and runway. For airline aircraft, such queuing delays are conservatively estimated to range up to 6 minutes per operation; for general aviation aircraft, queuing delays will frequently add as much as 8 minutes to each movement.

° The requirement for communications between the Boston control tower (ground control position) and aircraft on the ground will increase, adding to the work load of tower personnel and to the congestion on the ground control frequency. During the peak hour, additional ground control communications would be required strictly as the result of towing; they would add about 22% to ground control frequency occupancy time.

° For aircraft operations directly affected by the proposed towing regulations, tractor and ground crew assignment times per operation will be materially increased.

° Especially in the areas near the transfer zone, the traffic and congestion on airport service roads and terminal ramps will be substantially increased. Traffic increases will stem primarily from the necessity for tractors and other ramp-service vehicles to use such roads in moving between the terminal and the transfer zone. Additional congestion and service-road delays will result from the necessity to block such roads with aircraft in tow because the tractor-aircraft combination is longer than an aircraft alone and because the speed of towing is significantly less than that of taxiing.

° Especially in the transfer zone, the exposure of tugs (and ground crew personnel) to jet blast will reduce productivity at certain times.

° Outbound aircraft subject to the towing regulations that find it necessary to abort during or just after engine start-up will experience unusually large delays as a result of the necessity to return to the terminal. Especially during peak arrival times, this will add significantly to the congestion in the transfer zone since integration of such aircraft into the terminal-bound traffic stream will disrupt the routine flow of such traffic.

° Present gate-hold procedures would have to be modified extensively in the face of the towing program mandated by the Massport proposal if equitable treatment is to be guaranteed each aircraft operator. However, it may not even be possible to achieve this result employing the gate-hold concept without causing substantial additional congestion and much longer queuing delays at certain times of the day.

° There is a significant difference in the speed achievable by an aircraft being taxied and an aircraft-tractor combination moving over the relevant routes at Logan Airport. Between the airline ramps (Eastern and Allegheny) and the transfer zone, the differences are those between the 2 to 3 minutes required to taxi and the 5 to 8 minutes needed for towing.

° To facilitate engine starting it is often necessary to face certain aircraft directly into the prevailing wind. Conditions requiring this are sometimes encountered at Logan Airport and may create additional congestion and delays for air carriers with terminals near the transfer zone.

° Eastern Shuttle operations present a special problem in the context of the Massport towing proposal because of the extra-section policy employed. As shuttle activity increases and decreases in any given period of time, the effect on congestion in the transfer zone and along the pathways between Eastern's terminal and the zone are highly leveraged and affect many other operations including those of Eastern, Allegheny, Northwest (inbound), and general aviation.

ECONOMIC

General

° Many parties would be affected by the Massport towing proposals. Some operate on Logan Airport (e.g., Eastern Airlines, Allegheny Airlines, two FBO's, general aviation aircraft operators, employees of all of these organizations); others are not directly involved at Logan Airport on a routine basis, although they are influenced by it (e.g., residents of Jeffries Point, of Boston, of Massachusetts and of New England, and employees of New England industry and institutions).

° Especially for those most directly involved with Logan Airport, ultimate economic impact will be determined by their individual and collective reactions to the Massport towing rules once they are made operational. Without knowing what such reactions will be, it is impossible to determine with precision the economic implications of the Massport towing proposals. Also, the task is made more difficult because the reactions of affected parties can be expected to differ between the short run and the long run.

° The proposed Massport towing regulations discriminate between different carriers and operators at Logan Airport. That is, towing regulations do not impact each carrier or operator in the same way and the differences are very great--such as between Eastern and Delta, for example. This is not a result of any conscious effort on the part of Massport to be discriminatory, but is an inevitable outcome of these particular towing proposals.

Capital Investment Requirements

° Based upon December 1976 activity at Logan Airport, the two air carriers and the FBO's affected by the Massport towing proposals would have to acquire 14 new tractors (Eastern--5, Allegheny--3, FBO's--6), with an estimated total capital cost of $1,700,000.

° Additional capital investment would be required of the air carriers and of Massport for vehicles used by ramp service or supervisory personnel.

° Given the fact that aircraft ground times would be longer for aircraft subjected to long-distance towing, it follows that if either or both air carriers directly affected by the proposed towing regulations were to seek to maintain any given past or present level of service to Boston, substantial additional investment in aircraft would be necessary. While it is currently impossible to estimate precisely what capital would be required to meet this objective, it can be stated confidently that many millions of dollars would be involved.

Expense Streams

° With respect to Eastern Airlines' service at Logan, were this carrier to attempt to maintain service at the same level as in December 1976 after the Massport towing requirements were in effect (on a 24-hour-per-day basis), Eastern's annual operating costs would be increased about $1,200,000

at Logan Airport. A comparable figure for Allegheny Airlines, under the same assumption, would be approximately $800,000 per year.

° Some carriers other than those directly affected will also experience increased expenses as the result of the Massport towing proposals. Northwest Airlines is the most obvious case in point because of the present necessity for its inbound aircraft to taxi through the transfer zone enroute to the gates it uses in the South Terminal. The expense streams of all other operators will be increased as a result of heightened ground control frequency congestion during peak operating periods.

° Ground control frequency congestion problems might be alleviated by introduction of an additional ground control frequency at Logan Airport, but only if either FAA or Massport were willing to shoulder the cost burden.

° Certainly for the air carriers directly affected, and perhaps for GA aircraft operators, the FBO's and Massport, insurance premiums would rise as a result of actuarial calculations anticipating the greater risks associated with towing than taxiing. It has not been possible to determine the magnitude of these insurance cost increases for various parties, but they are likely to be sizable.

° Based upon a $50-per-round-trip tow charge to operators of general aviation aircraft requiring towing under the proposed regulations, and limiting such charges to those aircraft which use the general aviation terminal facilities of Butler and Van Dusen, general aviation aircraft owners would incur an additional annual cost of about $800,000 at Logan just for towing (based upon 1976 GA activity). Other costs for GA aircraft operators would result from the necessity for many GA aircraft--towed or not--to traverse the transfer zone with attendant delays, and also from added maintenance expenses associated with nose gear inspections and repairs.

° The annual cost of fuel consumed on Logan Airport would be decreased by approximately $140,000 annually, based on 1976 activity levels, as a result of implementation of the Massport towing proposals.

Revenue Effects

° Eastern Airlines would suffer substantial lost revenues from the imposition of Massport's towing requirements; Allegheny's revenues, if affected at all, would also decline. The receipts of other carriers competitive with Eastern and, perhaps, Allegheny would rise in view of traffic diversions from either or both of those two airlines.

° Eastern Airlines' Boston Shuttle revenues would be affected in an especially drastic and negative way, given the large proportional increase in scheduled time because of towing and the many alternative services offered by other air carriers in the Boston-New York market.

° Revenues for Eastern (and possibly Allegheny) would also be reduced through the decrease in available connections both at Boston and at

down-line stations. To the extent such traffic continued to move, however, revenues of competing carriers would be enhanced.

° The revenue (and profit) effects on connecting third-level carriers and Air New England is indeterminate, without additional data. It is clear, however, that none of these carriers serving Logan would enjoy increased revenues (or profits) as a result of the Massport towing requirements.

° While in the short run the revenues of Massport would not be affected materially by the towing requirements, it is conceivable that its revenues would decline at some point as the directly-affected air carriers and, perhaps, GA aircraft operators, began to limit or cut back operations at Logan Airport as the result of the increased costs of providing service and the increased difficulty of attracting traffic in competitive situations.

° Revenues of fixed-based operators at Logan Airport would rise as a result, primarily, of the towing fees being collected. Ultimately, FBO revenues from this source would be determined by GA aircraft owners' reactions to towing and by Massport's program for moving the GA terminal to eliminate GA aircraft towing.

Airline Service

° It is not possible to determine precisely what affect Massport's towing proposals would have on the quantity and pattern of airline services provided at Logan Airport. It is probable, however, that in the long run, if not in the short run, Eastern and/or Allegheny would reduce services or, especially for Allegheny, hold service to a level substantially below that which would obtain were there no such towing proposals.

° If and when either Eastern or Allegheny reduce service to Boston as a result of the imposition of the towing requirements, to the extent that competitive air carriers provide service in the same markets, overall service levels should continue to be maintained (even though the quality of such service may be reduced) given the diminution of effective competition.

Passenger Time Values

° Using widely-accepted measures, the value of additional time that airline passengers would have to devote to making trips to or from Boston on aircraft subject to the Massport towing proposals is approximately $6,900,000 annually, based upon the 1976 traffic experienced by Allegheny and Eastern.

Public Policy Issues

° Imposition of the Massport towing requirements would interfere with the competitive balance that now exists in many airline markets involving Boston.

° The competitive relationships in these markets has developed over many years, largely as a result of the Civil Aeronautics Board policy to employ competition as the principal means of ensuring that the public has airline service which is adequate in both quantitative and qualitative terms.

° The competitive relationships issue is especially glaring in those long-haul markets where Eastern, a relatively weak carrier financially, competes directly with financially strong carriers such as Delta. Any action which widens the disparity between such competitive carriers is inconsistent with Federal aviation policy.

° The highly innovative Eastern Air Shuttle service between Boston and New York-LaGuardia would be especially threatened by the Massport towing regulations. As a result, innovative and imaginative air services conceived for different markets might well be discouraged if entrepreneurs perceived that interstate commerce could be effected so profoundly by local or regional bodies.

° Imposition of Massport's towing proposals will probably increase the subsidy requirements of Allegheny Airlines whether or not this carrier maintains, expands, or contracts its services in Boston-oriented markets as a result of the towing program.

° In view of the critical importance to overseas air carriers of connecting traffic, to the extent the Massport towing proposals would make connections more difficult or discourage passengers from using Boston as an international gateway, Logan Airport would decline as a focal point for trans-Atlantic services. Certainly the public policy implications of this for Boston and for all of New England are very substantial and negative.

Noise and Jeffries Point

° For the Jeffries Point community, each unit reduction in NEF would be "worth" in terms of increased property values of about $480 thousand, $220 thousand, and $300 thousand in census tracts 512, 505, and 504, respectively. But it appears that the maximum increase in property values at Jeffries Point as a result of the imposition of Massport's towing proposals would stem from an improvement of one in the NEF for tract 512, or appoximately one-half million dollars.

ENVIRONMENTAL

Massport Assumptions

° There are insufficient data and knowledge either to support or to refute Massport's assumption to the effect that "aircraft taxiing noise is a significantly intrusive annoyance for the airport's neighbors who are located near apron, gate, and hangar areas. In these areas, taxiing aircraft generate noise substantially in excess of normal ambient levels."

Airport Noise Impacts in General

° Noise generated by aircraft while taxiing or while under tow (with or without an operating APU) is frequently totally masked by other noise-generating events. A substantial proportion of noise events emanate from airport operations (e.g., takeoffs, reverse thrust applications) but others are generated within the community where noise measurements are being taken.

o Insufficient data exist in either the literature or as a result of the present study to support a credible simulation of noise from taxiing or towed aircraft.

o The most reliable and appropriate data available are those gathered in the course of the Atlanta Airport Study (1973). Still, these data are not sufficient to permit the drawing of conclusions about noise impacts from taxiing aircraft; towed aircraft were not even considered in the Atlanta study. Based upon the Atlanta study and other data and information, however, it appears that any difference between taxi-generated noise and APU noise alone will be small, although probably in favor of the APU case.

Jeffries Point

o Noise tests conducted at Jeffries Point in February 1977 produced unquantifiable results as far as the ability to judge the net effect of the proposed Massport towing requirements is concerned. Nevertheless, these tests might be interpreted as supporting the general conclusion that taxiing aircraft, and aircraft under tow with an operating APU, would produce only slightly different noise impacts in much of the Jeffries Point community. Whatever the differences may be, they seem to favor the tow-plus-APU situation.

o Specifically with reference to Jeffries Point, even the possible advantage of towing over taxiing is frequently illusory given the fact that *other noise-producing events* were determined to mask totally the noise of either the tow-plus-APU situation or the taxiing aircraft.

o While no explicit data were gathered concerning the effect of the towing proposals on atmospheric pollution in Jeffries Point, it is probable that there would be a small reduction in such pollution were the Massport towing rules to be placed in effect depending on the dispersion of such pollutants.

o The emission of airborn pollutants from the operation of all aircraft would be reduced by less than 25% if the towing regulations were fully implemented.

o Certainly, substantial additional noise data must be gathered in the Jeffries Point area before a judgment can be made as to the "value" and benefits to the citizens of Jeffries Point associated with the implementation of the Massport towing requirements, whether on a full-time or partial basis.

Gellman Research Associates, Inc.

February 21, 1977

Mr. Richard E. Mooney
Director of Aviation
Massachussetts Port Authority
99 High Street
Boston, Massachussetts 02100

Dear Dick:

I am asking Earl Bomberger to bring this letter to Boston tomorrow, February 22, 1977, when he comes up to participate in the towing tests.

Primarily, Dick, I want to reiterate our understanding that Massport and our team are now working together to meet the common objective of determining the general feasibility of the "Massport towing proposals" as published in October, 1976. Indeed, it is our understanding that there is now but a single team and that Massport is part of it through the participation of yourself, your colleagues at Massport and your consultant, John Forsythe. As one manifestation of this relationship, we affirm that all data and information gathered and being developed for this study are freely available to you and expect the arrangement to be reciprocal. To this end, given John Forsythe's obvious expertise in the field of aircraft towing, I have enclosed with this letter a series of questions we are now addresssing which John can surely assist in answering.

Specifically concerning the towing to be performed on Wednesday (February 23), I hope it will be possible to have Massport officials participate in observing and timing the towing operations. While TSC will be taking noise readings, we will also be verifying Eastern's earlier towing results to the extent possible. As this is an especially sensitive area in many ways, it is important that Massport concur in the time estimates ultimately used to project the operations and capacity effects of aircraft towing.

100 west avenue jenkintown pennsylvania 19046 (215) 884-7500 Telex: 834653

Gellman Research Associates, Inc.

To: Mr. Richard E. Mooney
February 21, 1977
Page 2

Later this week, the UI/GRA members of the study team will have some rough draft material completed for consideration by the FAA and, of course, by Massport. In my view, this should be the last material submitted to FAA without your prior concurrence or demurrer and we are only submitting this material before your reaction is received because of prior contractural commitment to FAA in this regard.

We look forward to working with you on this project which we hope will be brought to a speedy and mutually agreeable conclusion through the cooperative effort upon which we are now embarked.

Cordially,

Aaron J. Gellman
President

AJG:ja
Enclosure

cc: Mr. James L. Hillman
Mr. Nicholas Krull

100 west avenue jenkintown pennsylvania 19046 (215) 884-7500

SOME UNRESOLVED SAFETY-RELATED ISSUES ASSOCIATED WITH THE MASSPORT TOWING PROPOSALS

1. In the course of towing, what maximum loads are imposed upon the nose landing gears of transport and general aviation aircraft of the types anticipated to be towed under the Massport proposals?

2. What do research results or experience to date indicate will be the likely affects of towing of the sort contemplated on aircraft frequently subject to such towing (e.g. Eastern's dedicated Shuttle fleet)?

3. Are there routine towing operations of the sort contemplated for Logan being conducted anywhere in the world? If so, where and with what results?

4. Given the configuration of the area in which aircraft engines will be started (the inner and/or outer taxiways and transitions between them in the vicinity of the fire station), what minimum spacing is permissible between aircraft and between aircraft and tugs of all possible combinations relevant to the Logan situation?

5. In the "transfer zone," is there any necessity for aircraft and/or tugs to communicate with one another? If so, what are such requirements?

6. What maximum towing speeds are achievable with various relevant tug/aircraft combinations? How will these vary with route of tow and with weather and pavement conditions?

7. How serious is the weathercocking potential of an aircraft/tug combination?

8. Is it prudent to allow aircraft to be in the "transfer zone" which have neither their propulsion engines operating nor a tug attached?

9. What difficulties or dangers, if any, would attend the starting of propulsion engines while an aircraft is under tow (not push-back)?

10. What attitudes have been expressed by the aviation insurance industry concerning the routine towing of loaded transport and general aviation aircraft?

APPENDIX B

ALLEGHENY AIRLINES

GREATER PITTSBURGH INTERNATIONAL AIRPORT   PITTSBURGH, PENNSYLVANIA 15231

January 11, 1977

Mr. Nick Krull
Federal Aviation Administration
AEQ-10 Room 836
800 Independence Avenue N.W.
Washington, D. C. 20591

Dear Mr. Krull:

In reply to your conversation with Mr. Garner W. Miller, Vice President-Maintenance and Engineering, regarding Allegheny's experiences with ground accidents resulting from towing operators, the most significant incident I can relate to is one that occurred in Boston on August 21, 1976.

The facts, as extracted from the investigation report, include (at approximately 2245 on August 21, 1976) Aircraft N985VJ was being towed to Allegheny's hangar by Maintenance personnel. As the aircraft approached the hangar ramp, the wheels on Huff Tractor #38 locked up and skidded approximately 3 feet on dry pavement. The sudden stoppage of the tractor resulted in the failure of the sheer bolts in towbar and excessive rearward torque loading of the nose gear when the towbar contracted to its minimum length. This action caused the failure of the nose gear drag strut attached, structure drag link, excessive damage to the station 110 pressure bulkhead and excessive structure damage to the frame below the station 110 bulkhead.

The aircraft came to rest with the nose gear upper housing cantered aft approximately 30° against the 110 bulkhead structure, restraining further nose down attitude and preventing the radome from coming to rest on the tractor.

The labor and material cost for this incident will total approximately \$200,000. This incident portrays the potential hazzard that exists during a towing operation where lack of coordinated commands between the cockpit and the tractor operator exist.

If we can be of any further assistance in providing information for your survey, feel free to contact me.

Sincerely,
ALLEGHENY AIRLINES, INC.

Wayne A. Suckow
Manager - Contracts/Budg

APPENDIX C

DOUGLAS AIRCRAFT COMPANY

3855 Lakewood Boulevard Long Beach, California 90846

February 23, 1977
C1-25-779

Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D. C. 20951

Attention: Mr. Nicholas Krull, AEQ-10

Gentlemen:

This letter is in reply to your request for a statement from the Douglas Aircraft Company on the impact of additional towing at Logan Airport on the structure of DC-8, DC-9 and DC-10 aircraft. It is understood that the additional towing will be 6/10ths mile inbound and outbound from the Southwest Terminal, that existing standard equipment will be used, and that towing will be at speeds less than 10 mph.

The Douglas comments are as follows:

1. Stringent additional inspections of the nose gear and backup structure will be required to minimize degradation of safety.
2. Increased cost and some degradation of safety can be expected due to undetected accidental damage resulting from towing over and above present operational standards.
3. The fatigue life of the nose gear and backup structure will be substantially reduced, possibly to only 5% of the present approved life.
4. Additional studies and tests are required to establish the necessary inspection program, to assess the increased risk of accidental damage, and to determine the reduced economic life.

Please feel free to call if we can further assist you in this matter.

Very truly yours,

M Stone

M. Stone, Director
Design Engineering
Structures

DSW:pn

MCDONNELL DOUGLAS
CORPORATION

APPENDIX D

BOEING COMMERCIAL AIRPLANE COMPANY

P.O. Box 3707
Seattle, Washington 98124

A Division of The Boeing Company

February 7, 1977
B-7701-1-262

Colonel Charles R. Foster
Director of Environmental Quality, AEQ-1
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D. C. 20591

Dear Chuck:

During your visit to Seattle, you asked for our evaluation of the effect of increased towing on airplane operation. We do not have a detailed structural analysis readily available. Further, there are no statistical data that show the number of aircraft damaged in towing operations. The following comments are believed pertinent, however, and would indicate that any significant addition to the towing requirement should be discouraged.

Boeing aircraft are designed for limited towing in order to manipulate in close quarters at passenger/cargo ramp facilities. There has been a history of damage occurring on nose landing gears at tow bar attach points even though most tow bar designs incorporate a structural fuse to limit high load introduction into the landing gear. Accidental damage has resulted in gear fracture in some cases. In addition, some operators have experienced fatigue cracking in nose gear and nose gear to body attaching structure as a result of repeated towing at constricted airport areas.

If aircraft were subjected to an increased amount of towing and/or increased towing speeds we would expect an increase in both the amount of handling damage to the nose gear at the tow bar attach points and the incidence of fatigue cracking in nose gear and nose gear attach structure. Also, close coordination between the tow vehicle driver and the airplane crew would be necessary to insure safe operation during an extended towing operation.

Usually damage resulting from towing operations, although costly, is not sufficient to be classified as an accident. Damage during taxi is also not well reported for the same reason. There are six recorded accidents during the taxi phase that may or may not have occurred if the airplane was being towed and a British Airway publication indicates it had six taxi incidents (damage sufficient to be classified as an accident) during the year 1976. If these data are translated into rates it would appear that taxi accidents occur at the rate of 0.08 per million flights and taxi incidents occur at a rate of 20.9 per million flights.

BOEING

There is no objective way of determining what would happen to these statistics if towing was substituted for taxiing. But since vehicle drivers are responsible for many damaged aircraft it would seem reasonable to expect an increase in airplane damage. The added congestion and confusion caused by the towing vehicles and other required ground support equipment and fire equipment moving along taxiways especially during night time and periods of low visibility could not help but be detrimental to safety. Proper supervision of airplane starting and final readiness would be more difficult than in the well lighted and well controlled ramp area.

All of the above would indicate added maintenance could be expected as towing was increased. In addition, it should be pointed out that considerable schedule delay could be encountered resulting from breakdowns on taxi-ways due to broken structural fuses, tow vehicle failures and airplane malfunctions discovered away from the ramp and requiring tow back for repair.

Certainly the airlines will recognize a negative passenger reaction to towbacks to the ramp that could otherwise be prevented by assuring airplane functional integrity prior to leaving the ramp area. A significant percentage (30% - 40%) of schedule delays are due to engine-related causes and can only be detected at the initiation of engine start-up and engine check-out. Furthermore some system checkouts cannot be completed unless engines are running.

The increase in the quantity of ground support equipment, such as tow trucks, tow bars, fire fighting equipment, etc., is pretty obvious.

If additional information are desired, please give us or Tom Mullen a call.

Sincerely,

for J L Copenhaver

H. W. Withington
Vice President -
Engineering

cc: Tom Mullen

APPENDIX E

STANFORD UNIVERSITY STANFORD, CALIFORNIA 94305

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS
WILLIAM F. DURAND BUILDING

3 February 1977

Mr. Aaron Gellman
100 West Ave.
Jenkintown, PA 19046

Dear Aaron:

In a phone call today you asked for my opinions about the structural effects of extended ground towing of fully loaded transport aircraft. Although I am by no means expert in the details of landing gear design, it seems clear that such an operating practice, implemented without any prior consideration of this operational mode in the landing gear design criteria could have serious effects on the structural life and integrity of the landing gear.

It is clear from the nature of both the take-off and landing operations that the usual horizontal operating loads are in the aft direction. A cursory review of the applicable Federal Air Regulations shows mention only of the aft or drag loads. Although I know of no structural problems of landing gears in general from forward towing, it seems clear that applying many cycles of forward loads due to towing fully loaded aircraft may well introduce fatigue failures never before encountered. Aircraft have never been operated in this manner.

Therefore, although I cannot say that such forward towing would cause damage, it would be most unwise to introduce high weight regular towing without a detailed analysis for each aircraft involved. Failure to do so raises the possibility of landing gear collapse incidents.

It was good talking with you again and I hope our paths will cross again in the near future.

Sincerely,

Dick

Richard S. Shevell
Professor of Aeronautics

RSS:ec

Enclosures

APPENDIX F

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE

INTRODUCTION

The gross effects of the proposed towing rule on airline operations and equipment requirements were estimated by simulating operations under the rule. The simulation takes into account the dynamic aspects of Eastern's and Allegheny's schedules, but ignores random deviations from schedules from whatever source. GA activity is quantified by a schedule based on mean value data. The results of this simulation are accordingly conservative.

SIMULATION

SCHEDULE GENERATION

Basic Data:

a. Eastern's Boston schedule.
b. Eastern Shuttle backup schedule.
c. Allegheny's Boston schedule.
d. Allegheny's gate assignment records.
e. Van Dusen records for 1976.
f. FAA Boston tower worksheets for 15 days (Jan 25, 77 to Feb 8, 77).

Scheduled Carriers:

Those flights currently handled by Allegheny on gates affected by the towing rule (gates 4, 6, 8, 10, 12, and 13) as shown by Allegheny's flight schedule were combined with Eastern's Boston schedule including hourly shuttle flights, and shuttle backup flights.

General Aviation:

General Aviation aircraft at Boston are handled by either Van Dusen Air Incorporated or Butler Aviation. The study group was unable to obtain Butler data and subsequently relied entirely on Van Dusen records.

During 1976, Van Dusen handled slightly over 1,200 general aviation, air taxi, and military aircraft. Of these, 1,098 records contain sufficient information for estimating the frequency distribution of aircraft arrivals on an hourly basis for a 24-hour day in the categories of a) propellor and b) turboprop and jet aircraft. The results of this compilation are shown in table F-1.

Estimates of the departure frequency distribution were obtained indirectly. It was judged that a more accurate estimate would be obtained by convoluting the frequency distribution of aircraft ground times (table F-2) with the arrival time frequency distribution (table F-1) than would be obtained directly

TABLE F-1

SUMMARY OF 1976 VAN DUSEN GENERAL AVIATION DATA

Time of Day	Annual Propeller Aircraft Arrivals	Annual Jet and Turbo-prop Arrivals	Total Arrivals	Percent Propeller	Percent Jet and Turbo-prop
0000-0100	5	8	13	38	62
-0200	3	12	15	20	80
-0300	1	0	1	100	0
-0400	1	2	3	33	67
-0500	0	0	0	-	-
-0600	0	0	0	-	-
-0700	9	5	14	64	36
-0800	56	15	71	79	21
-0900	93	26	119	78	22
-1000	64	40	104	62	38
-1100	61	43	104	59	41
-1200	43	38	81	53	47
-1300	37	31	68	54	46
-1400	35	29	64	55	45
-1500	28	27	55	51	49
-1600	26	34	60	43	57
-1700	33	28	61	54	46
-1800	34	37	71	48	52
-1900	31	28	59	53	47
-2000	13	19	32	41	59
-2100	13	14	27	48	52
-2200	12	17	29	41	59
-2300	19	7	26	73	27
-2400	12	9	21	57	43

Source: Van Duesen Records

TABLE F-2

FREQUENCY DISTRIBUTION OF GA AIRCRAFT GROUND TIMES FROM VAN DUSEN DATA

t mean ground time (hrs.)	fp propeller aircraft	fj jet & turbo prop aircraft	fp (%)	fj (%)
0.5	135	148	48.0	53.4
1.5	25	38	8.9	13.7
2.5	13	12	4.6	4.3
3.5	9	7	3.2	2.5
4.5	10	14	3.6	5.1
5.5	11	11	3.9	4.0
6.5	2	4	0.7	1.4
7.5	11	4	3.9	1.4
8.5	14	3	5.0	1.1
9.5	3	0	1.1	0
10.5	4	1	1.4	0.4
11.5	0	2	0	0.7
12.5	3	4	1.1	1.4
13.5	8	2	2.8	0.7
14.5	9	0	3.2	0
15.5	12	2	4.3	0.7
16.5	7	3	2.5	1.1
17.5	1	2	0.4	0.7
18.5	1	3	0.4	1.1
19.5	1	3	0.4	1.1
20.5	0	4	0	1.4
21.5	1	3	0.4	1.1
22.5	2	4	0.7	1.4
23.5	0	3	0	1.1
	281	277	100.5	98.8

Source: Van Duesen Records

from the available departure data. The departure time frequency distribution so obtained is shown in table F-3.

The number of general aircraft arrivals and departures by hour were generated by applying the distribution of tables F-1 and F-3 to daily general arrival and departure data obtained from FAA Boston Control Tower records. The calculation is shown in table F-4.

General aircraft arrival and departure times were assigned using standard random number techniques.

Eastern's Boston Air Shuttle activity is shown in table F-5. Arrival and departure times were obtained from Eastern Airline planning charts.

Table F-6 shows the nominal data used in the simulation. The supporting data and calculation are given in table F-7 through F-11.

SIMULATION RESULTS

The simulation is shown in table F-12. The following definitions apply:

a. Aircraft:

P GA propellor
J GA jet or turboprop

b. Flight number:

AL Allegheny
EA Eastern
GA General Aviation

c. Tugs:

A Allegheny
E Eastern
G General Aviation

d. Time tug assigned:

Tugs are assigned 5 minutes prior to a scheduled departure and 10 minutes prior to a scheduled arrival.

e. Tow start time:

Scheduled departure time if not blank. Blank indicates an arrival.

f. Aircraft at firehouse:

Scheduled arrival time of inbound flights. Calculated time at firehouse for outbound flights if no queuing delay occurs.

g. Queuing delay:

Calculated from tow or taxi start of aircraft preceding in queue. Includes additional towing time and waiting time.

h. Tow or taxi start:

Tow start time of inbound aircraft and taxi start time of outbound aircraft including queuing delay of towed.

i. Tug at gate or ready to reassign:

Arrival at gate of inbound aircraft including queuing delay. Taxi start plus 5 minutes for tugs towing outbound aircraft.

SPECIAL SEQUENCES

Sequence #1:

The occurring outbound operation sequence between 0705 and 0736 is examined in detail in table F-13 and figures F-1 through F-12.

Sequence #2:

The sequence of operations between 1800 and 1826 is shown in section III.

TABLE F-3

ESTIMATED DEPARTURE DISTRIBUTION
OF 1976 VAN DUSEN HANDLED AIRCRAFT*

Time of Day	Departure P	Departure T & J	Departure Total	% P	% TJ
0000-0100	18.6	10.8	29.4	63.3	36.7
-0200	15.2	12.8	28.0	54.3	45.7
-0300	11.5	6.6	18.1	63.5	36.5
-0400	9.8	6.2	16.0	61.2	38.8
-0500	8.0	5.3	13.3	60.2	39.8
-0600	8.0	5.2	13.2	60.6	39.4
-0700	11.4	7.4	18.8	60.6	39.4
-0800	33.7	13.2	46.9	71.9	28.1
-0900	55.4	20.2	75.6	73.3	26.7
-1000	46.0	29.3	75.3	61.1	38.9
-1100	44.6	33.5	78.1	57.1	42.9
-1200	36.8	32.4	69.2	53.2	46.8
-1300	34.5	29.5	64.0	53.9	46.1
-1400	33.2	28.4	61.6	53.9	46.1
-1500	31.2	27.6	58.8	53.1	46.9
-1600	32.3	30.7	63.0	51.3	48.7
-1700	31.0	28.0	59.0	52.5	47.5
-1800	31.8	31.5	63.3	50.2	49.8
-1900	29.1	27.4	56.5	51.5	48.5
-2000	19.8	21.6	41.4	47.8	52.2
-2100	19.8	17.7	37.5	52.8	47.2
-2200	20.5	18.5	39.0	52.6	47.4
-2300	25.1	13.0	38.1	65.9	34.1
-2400	23.6	12.1	35.7	66.1	33.9
	630.9	468.9	1009.8		

*Obtained by convolution of 1976 Van Dusen arrival distribution (Table F-1) with Van Dusen ground time distribution (Table F-2).

Source: GRA

TABLE F-4

ESTIMATED DAILY G.A. ACTIVITY
FROM VAN DUSEN DATA & FAA TOWER RECORDS

Time of Day	(1) Daily GA Arrivals	(2) % Propeller	Est. Daily G.A. Prop Arrivals	Est. Daily G.A. Turbo-prop & Jet Arrivals	(1) Daily G.A. Departures	(3) % Propeller	Est. Daily G.A. Prop. Departures	Est. Daily G.A. Turbo-prop & Jet Departures
0000-0100	2	38	1	1	2	63	1	1
-0200	1	20	0	1	1	54	1	0
-0300	1	100	1	0	1	64	1	0
-0400	1	33	0	1	1	61	1	0
-0500	1	-	0	1	1	60	1	0
-0600	2	-	1	1	2	61	1	1
-0700	1	64	1	0	1	61	1	0
-0800	1	79	1	0	1	72	1	0
-0900	4	78	3	1	2	73	1	1
-1000	8	62	5	3	4	61	2	2
-1100	7	59	4	3	7	57	4	3
-1200	6	53	3	3	6	53	3	3
-1300	7	54	4	3	7	54	4	3
-1400	6	55	3	3	8	54	4	4
-1500	5	51	3	2	5	53	3	2
-1600	6	43	3	3	7	51	4	3
-1700	7	54	4	3	7	52	4	3
-1800	8	48	4	4	7	50	4	3
-1900	9	53	5	4	5	52	3	2
-2000	7	41	3	4	10	48	5	5
-2100	5	48	2	3	5	53	3	2
-2200	3	41	1	2	3	53	2	1
-2300	1	73	1	0	2	66	1	1
-2400	3	57	2	1	3	66	2	1

(1) Estimated from FAA Boston Tower Traffic Work Sheets for the period 1-25-77 to 2-8-77.
(2) See Table F-1.
(3) See Table F-2.

Source: GRA

TABLE F-5

BOSTON AIR SHUTTLE

Average Extra Section Activity Except July-Aug.

HOURS	MON		TUES		WED		THUR		FRI		SAT		SUN	
	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In
0700	1		1		1		1				No	Op	No	Op
0800	2	1	2	1	2	1	2	1	1		No	Op	No	Op
0900	1	2	2	2	2	2	1	2	1	1				
1000		1	1	1	1	2	1	1		1	1			
1100		1		1	1	1	1	1				1		
1200														
1300									1					
1400							1		1	1				
1500	1		1		1		1	1	2	2			1	
1600	1	1	1	1	2	1	1	1	2	2			1	1
1700	1	1	1	1	1	2	2	2	2	2			1	1
1800	1	1	1	1	1	2	2	2	2	2			1	1
1900		1		1	2	1	1	2	1	2	No	Op		
2000				1		1	1	1	1	2		No-Op	1	1
2100			1						1	1	Noop		1	1
2200												No-op		1
2300														1

Source: EAL Planning Department

TABLE F-6

NOMINAL DATA FOR TOWING SIMULATION

TOW OUT OPERATION

Type A/C	Towing Time (min.)*	Starting Time (min.)	Towing Speed (ft/min)	Towing Dist. (ft.)
GA	9	2	500	5000
DC9	9	2	500	3600
727	10	2	400	3600
L1011	12	11	350	2650

* Includes push back time.

TOW IN OPERATION

Type A/C	Towing Time	Hookup Time (min.)	Towing Speed (ft/min)	Towing Dist. (ft)
GA	8	1	400	5000
DC9	8	1	400	3450
727	7	2	400	3450
L1011	6	4	400	2650

NO TOW OPERATION

Operator	Taxi In	Taxi Out
Allegheny	2	2
GA	3	3

SPACING BETWEEN TOWED AIRCRAFT

DC9	200'
727	200'
L1011	300'

LENGTH OF AIRCRAFT WITH TRACTOR

	A/C Length	+	Tractor	=	Total
DC9	104'	+	20'	=	124'
727	133'	+	20'	=	153'
L1011	178'	+	26'	=	204'

Source: GRA

TABLE F-7

DISTANCES FROM EAL GATES TO FIREHOUSE

Gate No.	DISTANCES (FT) Inbound	Outbound
1	3650	3650
2	3450	3450
3	3250	3250
4	2850	2850
5	2750	2750
6*	2650	2650
7	3750	4050
8	3450	3750
9	3450	3750
10	3550	3850
11	3750	4250
12	3950	4250
Total**	37850	39650
Mean**	3440	3600

* Used primarily by L1101
** Excluding Gate 6

(Source: GRA)

TABLE F-8

MEASURED TAXIWAY SPEEDS-CURRENT OPERATION

TYPE A/C	DIR.	DISTANCE	TIME	SPEED
GA	In	1325 ft.	51 sec.	26 ft/sec
GA	Out	3060	126	25
DC9	In	1345	60	22
DC9	Out	2930	111	26
GA	Out	3480	114	31
DC9	In	925	27	34
DC9	Out	925	46	20
DC9	Out	3380	108	31
GA	Out	925	35	26
727	Out	1345	58	23
DC9	Out	1965	69	28
GA	In	1705	64	27
GA	In	1325	53	25
GA	Out	2135	73	29
DC9	In	820	20	41
727	Out	1805	70	26
GA	Out	3060	80	38
			Sum	478
			No. of Obs.	17
			Mean	28 ft/sec 19 mph

Source: GRA

TABLE F-9
SUMMARY OF EAL TOWING DATA

Outbound Operations

A/C A/C	Actual Departure	Stop at Firehouse	Towing** Time (min.)	Taxi Start	Start up Time (min.)	Total Tow Time (min.)	Tractor at Terminal	Active Tractor Time	Gate No.	Towing Dist. (ft.)
DC9	1040	1048	8	1050	2	10	1054	14	5	2750
"	1238	1246	8	1248	2	10	1252	14	4	2850
"	1416	1426	10	1427	1	11	1432	16	8	3750
"	1500	1508	8	1509	1	9	1517	17	8	3750
"	1829	1839	10	1840	1	11	1844	15	1	3650
"	0724	0735	11	0737	2	13	0739	15	1	3650
"	1204	1213	9	1215	2	11	1219	15	8	3750
			64		11	75		106		24150
		Mean	9.14		1.57	10.7		15.1		3450
727	1730	1736	6	1737	1	7	1740	10	5	2750
"	1910	1918	8	1919	1	9	1922	12	5	2750
"	0700	0710	10	0712	2	12	0714	14	4	2850
"	0710	0724	14	0726	2	16	0732	22	2	3450
"	1910	1919	9	1923	4	13	1924	14	4	2850
"	1408	1421	13	1424	3	16	1426	18	2	3450
			60		13	73		90		18100
		Mean	10.0		2.17	12.2		15.0		3017
L1011	1003	1014	11	1021	7	18	1028	25	6	2650
"	0923	0933	10	0943	10	20	0946	23	6	2650
"	1056	1111	15	1121	10	25	1123	27	6	2650
"	1022	1034	12	1049	15	27	1051	29	6	2650
"	0844	0855	11	0910	15	26	0914	30	6	2650
"	1055	1020	15*	1027	7	22	1030	25	6	2650
			74		64	138		159		
			4							
			70							
		Mean	11.7		10.7	23.0		26.5		2650

*Tow held 4 min. for clearance
**Includes pushback

Source: EAL Towing Study

TABLE F-10

SUMMARY OF EAL TOWING DATA

Inbound Operations

A/C	Sched. Arrival	A/C Stop at Firehouse	Tow Start Time	Hookup Time (min.)	Time at Gate	Towing Time (min.)	Total Tow Time (min.)	Tractor Left Terminal	Tractor Time (min.)	Gate	Towing Distances
DC9	1149	1154	1155	1	1204	9	10	1138	26	4	2850
"	1345	1349	1348	1	1356	8	9	1335	21	8	3450
"	1149	1252	1253	1	1302	9	10	1250	12	4	2850
"	2057	2059	2101	2	2108	7	9	2050	18	1	3650
				5		33	38		77		12800
			Mean	1.25		8.25	9.5		19.25		3200
727	1315	1370	1312	2	1318	6	8	1306	12	2	3450
"	1402	1420	1421	1	1428	7	8	1356	32	5	2750
"	1945	1956	1957	1	2007	10	11	1935	32	2	3450
"	2100	2049	2051	2	2057	6	8	2042	15	4	2850
"	0930	0942	0945	3	0953	8	11	0720	33	2	3450
				9		37	46		124		15950
			Mean	1.8		7.4	9.2		24.8		3190
L1011	2131	2153	2154	1	2202	8	9	2132	30	6	2650
"	1800	1816	1821	5	1827	6	11	1753	34	6	2650
	2131	2133	2137	4	2142	5	9	2127	15	6	2650
"	1800	1756	1802	6*	1808	6	12*	1750	18	6	2650
				16		25	41		97		
			Mean	4.0		6.25	10.25		24.24		2650

*Unusual tractor to aircraft communication problem accounted for 1.5 minutes.

Source: EAL Towing Study

TABLE F-11

ESTIMATED TOWING SPEED UNDER PROPOSED RULE

OUTBOUND

A/C	N	Towing[1] Time(min)	Pushback[2] Time (min)	Net Towing Time (min)	Mean Towing Distance (ft)	Mean Towing Speed (ft/min.[1])
DC9	7	9.14	2	7.14	3450	483
727	6	10.0	2	8.00	3017	377
L1011	6	11.7	4	7.7	2650	344

INBOUND

A/C	N	Mean Towing Time (min)	Mean Towing Distance (ft)	Mean Towing Speed (ft/min)
DC9	4	8.25	3200	388
727	5	7.40	3190	431
L1011	4	6.25	2650	424

[1] From EAL study. Includes push back time
[2] Estimated by GRA

Source: GRA

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
P	GA	-	-	0015	0018	-	0018	-
J	GA	G1	0005	-	0015	-	0016	0024
J	GA	G1	0030	0035	0044	-	0046	0051
P	GA	-	-	-	0045	-	-	0048
727	EA418	E1	0047	-	0052	-	0054	0101
J	GA	G2	0050	-	0100	-	0101	0109
P	GA	-	-	0150	0153	-	0153	-
727	EA114	E1	0132	-	0142	-	0144	0151
P	GA	-	-	0250	0253	-	0253	-
P	GA	-	-	-	0300	-	-	0303
72S	EA486	E1	0327	-	0337	-	0339	0346
P	GA	-	-	0355	0358	-	0358	-
J	GA	G1	0350	-	0400	-	0401	0409
P	GA	-	-	0500	0503	-	0503	-
P	GA	-	-	-	0525	-	-	0528
J	GA	G1	0530	-	0540	-	0541	0549
P	GA	-	-	0545	0548	-	0548	-
J	GA	G2	0540	0545	0554	-	0556	0601
72S	EA889	E1	0555	0600	0610	-	0612	0617
727	EA379	E2	0555	0600	0610	3	0615	0620
P	GA	-	-	-	0610	-	-	0613
P	GA	-	-	0630	0633	-	0634	-
72S	EA727	E1	0632	0637	0647	-	0649	0654
D9S	AL145	A1	0640	0645	0654	-	0656	0701
D9S	AL291	-	-	0650	0653	3	0656	-
B11	AL411	A2	0655	0700	0709	-	0711	0716
D9S	EA1001	E1	0655	0700	0709	3	0714	0719
727	EA517	E2	0655	0700	0710	5	0717	0724
B11	AL487	A3	0655	0700	0709	9	0720	0722

Source: GRA

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
D9S	AL225	-	-	0710	0712	9	0720	-
DC9	Shuttle	E1	0705	0710	0719	2	0723	0726
727	EA69	E3	0705	0710	0720	4	0723	0728
D9S	AL165	A1	0708	0713	0722	5	0729	0730
D9S	AL21	-	-	0720	0722	7	0729	-
DC9	EA149	E4	0715	0720	0729	1	0732	0736
D9S	EA377	E5	0715	0720	0729	4	0735	0738
P	GA	-	-	0725	0728	7	0735	-
D9S	AL155	-	-	0730	0732	4	0738	-
727	EA187	E1	0730	0735	0745	-	0747	0752
P	GA	-	-	-	0735	-	-	0738
D9S	EA2160	E2	0733	-	0743	-	0744	0752
J	GA	G1	0740	-	0750	-	0751	0759
D9	Shuttle	E1	0742	-	0752	-	0753	0801
727	EA528	E3	0744	-	0754	-	0756	0803
D9S	EA1011	E1	0755	0800	0809	-	0811	0816
727	EA605	E2	0755	0800	0809	3	0814	0819
J	GA	G1	0800	-	0810	-	0811	0819
DC9	Shuttle	E3	0805	0810	0819	-	0821	0826
DC9	Shuttle	E4	0805	0810	0819	-	0828	0828
P	GA	-	-	0820	0823	3	0823	-
D95	AL24	-	-	-	0826	-	-	0828
D9S	AL274	-	-	-	0827	-	-	0829
L10	EA601	E1	0825	0830	0842	-	0853	0858
J	GA	G1	0830	0835	0844	10	0856	0901
P	GA	-	-	-	0835	-	-	0838
P	GA	-	-	-	0835	-	-	0838
72S	EA867	E2	0835	0840	0850	7	0859	0904

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
P	GA	-	-	-	0840	-	-	0843
D9S	EA536	E3	0832	-	0842	-	0843	0851
D9S	EA2010	E4	0842	-	0852	-	0853	0901
D9	Shuttle	E6	0840	-	0858	-	0859	0907
D9	Shuttle	E7	0840	-	0858	2	0900	0959
72S	EA41	E3	0855	0900	0910	-	0912	0917
D9S	EA1021	E5	0855	0900	0909	4	0915	0920
D9S	AL199	-	-	0900	0902	-	0902	-
D95	AL3	-	-	0905	0907	8	0915	-
J	GA	G1	0900	0905	0914	2	0918	0923
D9S	AL20	-	-	-	0905	-	-	0907
727	EA881	E1	0905	0910	0920	-	0922	0927
D9	Shuttle	E4	0905	0910	0919	4	0925	0930
D9S	AL154	-	-	-	0912	-	-	0914
B11	AL368	A1	0903	-	0913	-	0914	0922
P	GA	-	-	0915	0918	7	0925	-
B11	AL350	A2	0908	-	0918	-	0919	0927
P	GA	-	-	-	0920	2	-	0925
J	GA	G2	0915	-	0925	-	0926	0934
D9S	EA869	E2	0925	0930	0939	-	0941	0946
P	GA	-	-	-	0930	-	-	0933
J	GA	G3	0920	-	0930	-	0931	0939
727	EA398	E3	0920	-	0930	2	0934	0941
B11	AL454	A1	0922	-	0932	3	0936	0944
J	GA	G1	0935	0940	0949	-	0951	0958
D9S	EA650	E1	0938	-	0948	-	0949	0957
P	GA	-	-	0950	0953	-	0953	-
P	GA	-	-	-	0950	-	-	0953

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
P	GA	-	-	-	0950	-	-	0953
D9S	EA202	E3	0944	-	0954	-	0955	1003
B11	AL353	A1	0950	0955	1004	-	1006	1011
J	GA	G2	0945	-	0955	-	0956	1004
D9	Shuttle	E6	0949	-	0959	-	1000	1008
D9S	EA1031	E2	0955	1000	1009	-	1011	1016
L10	EA945	E4	0955	1000	1012	-	1023	1028
P	GA	-	-	-	1000	-	-	1003
727	EA562	E5	0954	-	1004	-	1006	1013
P	GA	-	-	1005	1008	15	1023	-
B11	AL357	A2	1003	1008	1017	7	1026	1031
B11	AL407	A3	1005	1010	1019	8	1029	1034
P	GA	-	-	-	1010	-	-	1013
J	GA	G1	1005	-	1015	-	1016	1024
727	EA145	E1	1015	1020	1030	-	1032	1037
J	GA	G2	1015	1020	1029	4	1035	1040
P	GA	-	-	-	1020	-	-	1023
D9S	AL144	-	-	-	1023	-	-	1026
J	GA	G3	1020	1025	1034	2	1038	1043
J	GA	G4	1020	1025	1034	5	1041	1046
P	GA	-	-	1025	1028	7-13	1035	-
D9S	AL	-	-	1030	1033	8	1041	-
P	GA	-	-	-	1035	-	-	1038
J	GA	G1	1025	-	1035	-	1036	1044
B11	AL488	-	-	-	1038	1	-	1042
D9S	EA567	E2	1035	1040	1049	-	1051	1056
D95	AL7	-	-	1040	1042	-	1042	-
P	GA	-	-	1040	1043	-	1043	-

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
D9S	AL288	-	-	-	1041	-	-	1044
P	GA	-	-	-	1045	-	-	1048
J	GA	G5	1035	-	1045	-	1046	1054
D9S	EA2030	E1	1040	-	1050	-	1051	1059
P	GA	-	-	1055	1058	-	1058	-
D9	Shuttle	E6	1048	-	1058	-	1059	1107
727	EA178	E3	1049	-	1059	-	1101	1108
D9S	EA1040	E4	1055	1100	1109	-	1111	1116
727	EA57	E2	1057	1102	1112	-	1114	1119
727	EA834	E5	1057	-	1107	-	1109	1116
P	GA	-	-	-	1110	1	-	1114
J	GA	G1	1110	1115	1124	-	1126	1131
J	GA	G2	1110	1115	1124	3	1129	1134
J	GA	G3	1115	1120	1129	1	1132	1139
P	GA	-	-	1125	1128	4	1132	-
P	GA	-	-	-	1130	-	-	1133
P	GA	-	-	-	1135	-	-	1138
D9S	AL115	-	-	1136	1138	-	1138	-
B11	AL455	-	-	1135	1138	-	1138	-
P	GA	-	-	1135	1138	-	1138	-
727	EA148	E1	1128	-	1138	-	1140	1147
J	GA	G4	1130	-	1140	-	1141	1149
D9S	EA2040	E2	1138	-	1148	-	1149	1157
D9S	EA878	E3	1139	-	1149	-	1150	1158
P	GA	-	-	1150	1153	-	1153	-
727	EA133	E4	1145	1150	1200	-	1202	1207
J	GA	G1	1140	-	1150	-	1151	1159
D9S	EA1051	E1	1155	1200	1209	-	1211	1216
J	GA	G2	1150	-	1200	-	1201	1209

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
P	GA	-	-	-	1215	-	-	1218
B11	AL436	-	-	-	1215	-	-	1217
D9S	AL140	A1	1205	-	1215	-	1216	1224
D9S	AL2	A2	1206	-	1216	-	1217	1225
P	GA	-	-	1220	1223	-	1223	-
727	EA845	E2	1215	1220	1230	-	1232	1237
P	GA	-	-	-	1225	-	-	1228
J	GA	G1	1215	-	1225	-	1226	1234
727	EA179	E1	1222	1227	1237	-	1239	1244
B11	AL470	-	-	-	1228	-	-	1230
727	NW282	-	-	-	1229	-	-	1231
P	GA	-	-	1230	1233	6	1239	-
J	GA	G2	1220	-	1230	-	1231	1239
B11	AL352	A3	1230	-	1230	2	1233	1241
J	GA	G3	1230	1235	1244	-	1246	1251
P	GA	-	-	-	1235	-	-	1238
J	GA	G4	1225	-	1235	-	1236	1244
D9S	AL28	-	-	-	1236	1	-	1239
D9S	EA533	E3	1233	1238	1247	-	1249	1254
P	GA	-	-	1240	1243	3	1246	-
D9S	AL244	A1	1230	-	1240	-	1241	1249
D9S	EA2050	E2	1239	-	1249	-	1250	1258
J	GA	G1	1245	1250	1259	-	1301	1306
J	GA	G2	1250	1255	1304	-	1306	1311
D9S	AL241	-	-	1255	1257	4	1301	-
B11	AL473	-	-	1300	1302	4	1306	-
D9S	EA1061	E1	1255	1300	1309	-	1311	1316
P	GA	-	-	1300	1303	3	1306	-
P	GA	-	-	-	1300	-	-	1303

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
B11	AL431	A1	1300	1305	1314	-	1316	1321
J	GA	G3	1300	1305	1314	3	1319	1324
727	EA54	E2	1305	-	1315	-	1317	1324
B11	AL481	A2	1315	1320	1329	-	1331	1336
D9S	AL91	A3	1315	1320	1329	3	1334	1339
J	GA	G1	1315	1320	1329	6	1337	1342
P	GA	-	-	1325	1328	9	1337	-
J	GA	G2	1315	-	1325	-	1326	1334
D9S	AL25	-	-	1330	1332	5	1337	-
J	GA	G4	1320	-	1330	-	1331	1339
P	GA	-	-	1335	1338	-	1338	-
P	GA	-	-	-	1335	-	-	1338
P	GA	-	-	-	1335	-	-	1338
P	GA	-	-	-	1335	-	-	1338
J	GA	G2	1335	1340	1349	-	1351	1356
J	GA	G3	1330	-	1340	-	1341	1349
P	GA	-	-	1345	1348	3	1351	-
D9S	AL128	A1	1335	-	1345	-	1346	1354
D9S	EA2060	E1	1339	-	1349	-	1350	1358
P	GA	-	-	1350	1353	-	1353	-
D9S	AL183	A2	1345	1350	1359	-	1401	1406
D9S	AL238	-	-	-	1356	-	-	1358
D9S	EA1071	E2	1355	1400	1409	-	1411	1416
J	GA	G1	1355	1400	1409	3	1414	1419
728	EA868	E3	1352	-	1402	-	1404	1411
727	EA383	E1	1400	1405	1415	-	1417	1422
B11	AL498	A1	1401	-	1411	-	1412	1420
727	EA534	E4	1405	-	1415	-	1417	1424
J	GA	G2	1410	-	1420	-	1421	1429

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
D9S	AL240	-	-	-	1422	1	-	1425
P	GA	-	-	-	1425	1	-	1429
J	GA	G3	1415	-	1425	-	1426	1434
P	GA	-	-	1440	1443	-	1443	-
J	GA	G1	1440	1445	1454	-	1456	1501
D9S	EA2070	E1	1439	-	1449	-	1450	1458
D9S	EA882	E2	1439	-	1449	2	1452	1500
P	GA	-	-	1450	1453	3	1456	-
P	GA	-	-	1450	1453	3	1456	-
J	GA	G2	1445	1450	1459	-	1501	1506
P	GA	-	-	-	1450	9	-	1502
P	GA	-	-	-	1450	9	-	1502
B11	AL402	A1	1440	-	1450	3	1454	1502
B11	AL377	A2	1450	1455	1504	-	1506	1511
D9S	EA1081	E3	1455	1500	1509	-	1511	1516
D9S	AL179	-	-	1500	1503	3	1506	-
72S	EA549	E4	1455	1500	1510	2	1514	1519
D9	Shuttle	E6	1456	1501	1510	5	1517	1522
727	EA372	E5	1452	-	1502	-	1504	1511
727	EA43	E1	1505	1510	1520	-	1522	1527
P	GA	-	-	1515	1518	-	1518	-
D9S	AL233	A1	1510	1515	1524	-	1526	1531
J	GA	G1	1505	-	1515	-	1516	1524
P	GA	-	-	1520	1523	3	1526	-
727	NW	-	-	-	1524	-	-	1526
P	GA	-	-	1530	1533	-	1533	-
B11	AL405	A2	1525	1530	1539	-	1541	1546
J	GA	G2	1520	-	1530	-	1531	1539
J	GA	G1	1530	1535	1544	-	1546	1551

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
J	GA	G3	1525	-	1535	-	1536	1544
P	GA	-	-	1540	1543	3	1546	-
727	EA505	E1	1535	1540	1550	-	1552	1557
P	GA	-	-	-	1540	-	-	1543
D9S	AL214	A1	1531	-	1541	-	1542	1550
D9S	AL211	-	-	1545	1547	5	1552	-
J	GA	G2	1540	1545	1554	-	1556	1601
P	GA	-	-	-	1545	-	-	1548
D9S	AL246	-	-	-	1546	-	-	1548
D9S	EA2080	E2	1539	-	1549	-	1550	1558
J	GA	G3	1545	1550	1559	-	1601	1606
727	EA199	E3	1547	1552	1602	-	1604	1609
P	GA	-	-	-	1555	-	-	1558
D9	Shuttle	E6	1546	-	1556	-	1557	1605
72S	EA880	E4	1549	-	1559	-	1601	1608
D9S	EA1091	E5	1555	1600	1609	-	1611	1616
P	GA	-	-	-	1600	4	-	1607
B11	AL446	-	-	-	1603	1	-	1606
P	GA	-	-	1605	1608	3	1611	-
J	GA	G1	1555	-	1605	-	1606	1614
J	GA	G2	1605	1610	1619	-	1621	1626
D9	Shuttle	E1	1605	1610	1619	3	1624	1629
D9S	AL138	A1	1600	-	1610	-	1611	1619
J	GA	G4	1605	-	1615	-	1616	1624
J	GA	G5	1605	-	1615	2	1618	1626
B11	AL372	-	-	-	1628	-	-	1630
D9S	AL297	-	-	1630	1632	-	1632	-
D9S	AL159	A1	1625	1630	1639	-	1641	1646

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
J	GA	G1	1630	1635	1644	-	1646	1651
P	GA	-	-	-	1640	-	-	1643
D9S	AL282	-	-	-	1640	-	-	1642
727	EA42	E1	1630	-	1640	-	1642	1649
B11	AL410	A2	1630	-	1640	3	1644	1652
P	GA	-	-	1645	1648	-	1648	-
P	GA	-	-	1645	1648	-	1648	-
P	GA	-	-	-	1645	-	-	1648
727	EA8	E2	1635	-	1645	-	1647	1654
72S	EA129	E3	1645	1650	1700	-	1702	1707
P	GA	-	-	-	1650	-	-	1653
D9S	EA2090	E4	1641	-	1651	-	1652	1700
D9S	EA866	E5	1644	-	1654	-	1655	1703
B11	AL408	A3	1645	-	1655	-	1656	1704
D9	Shuttle	E6	1649	-	1659	-	1700	1708
P	GA	-	-	1700	1703	-	1703	-
P	GA	-	-	1700	1703	-	1703	-
J	GA	G1	1655	1700	1709	-	1711	1716
B11	AL355	-	-	1700	1702	-	1702	-
D9S	EA1101	E1	1655	1700	1709	2	1713	1718
D9S	AL281	A1	1655	1700	1709	4	1715	1720
J	GA	G2	1655	-	1705	-	1706	1714
P	GA	-	-	1710	1713	2	1715	-
D9	Shuttle	E4	1705	1710	1719	-	1721	1726
727	EA116	E2	1700	-	1710	-	1712	1719
B11	AL381	-	-	1715	1718	-	1718	-
P	GA	-	-	-	1715	-	-	1718
D9S	AL137	-	-	1720	1722	-	1722	-
J	GA	G2	1715	1720	1729	-	1731	1736

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
B11	AL425	A2	1715	1720	1729	3	1734	1739
J	GA	G1	1720	1725	1734	-	1736	1741
P	GA	-	-	-	1730	-	-	1733
P	GA	-	-	1735	1738	-	1738	-
P	GA	-	-	-	1740	-	-	1743
72S	EA538	E1	1730	-	1740	-	1742	1748
J	GA	G3	1730	-	1740	3	1744	1752
B11	AL379	A1	1739	1744	1753	-	1755	1800
J	GA	G4	1735	--	1745	-	1746	1754
P	GA	-	-	1750	1753	2	1755	-
D9S	EA359	E2	1745	1750	1759	-	1801	1806
B11	AL354	-	-	-	1750	-	-	1752
J	GA	G2	1740	-	1750	-	1751	1759
D9S	EA2100	E3	1744	-	1754	-	1755	1803
J	GA	G1	1750	1755	1804	-	1806	1811
727	EA348	E4	1745	-	1755	-	1757	1804
727	EA47	E1	1755	1800	1810	-	1812	1817
D9S	EA1111	E5	1755	1800	1809	4	1815	1819
D9	Shuttle	E7	1749	-	1759	-	1800	1809
P	GA	-	-	-	1800	5	-	1808
P	GA	-	-	-	1800	5	-	1808
D9	Shuttle	E8	1750	-	1800	2	1803	1811
L10	EA604	E6	1750	-	1800	4	1809	1815
P	GA	-	-	1805	1808	8	1816	-
J	GA	G3	1755	-	1805	4	1810	1822
J	GA	G4	1755	-	1805	7	1812	1824
J	GA	G5	1755	-	1805	8	1814	1826
D9	Shuttle	E3	1805	1810	1819	0	1821	1826
D9	Shuttle	E4	1805	1810	1819	2	1825	1828

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
D9S	AL168	A1	1801	-	1811	4	1816	1824
727	EA600	E2	1800	-	1816	1	1818	1825
P	GA	-	-	-	1820	3	-	1826
J	GA	G1	1820	1825	1834	-	1836	1841
P	GA	-	-	-	1825	-	-	1828
B11	AL467	A1	1830	1835	1844	-	1846	1851
P	GA	-	-	-	1840	-	-	1843
P	GA	-	-	-	1840	-	-	1843
J	GA	G2	1830	-	1840	-	1841	1849
D9S	AL186	A2	1831	-	1841	-	1842	1850
P	GA	-	-	1845	1848	-	1848	-
72S	EA535	E1	1840	1845	1855	-	1857	1902
D9S	AL26	A3	1836	-	1846	-	1847	1855
D9S	EA2110	E2	1844	-	1854	-	1855	1903
D9	Shuttle	E4	1851	-	1901	-	1902	1910
P	GA	-	-	1900	1903	-	1903	-
J	GA	E1	1855	1900	1909	-	1911	1916
D9S	EA1121	E3	1855	1900	1909	3	1914	1919
P	GA	-	-	1905	1908	6	1914	-
P	GA	-	-	1905	1908	6	1914	-
D9S	AL245	A1	1904	1909	1918	-	1920	1925
72S	EA537	E1	1905	1910	1920	-	1922	1927
727	EA651	E2	1905	1910	1920	3	1925	1930
J	GA	G2	1905	1910	1919	7	1928	1933
D9	Shuttle	E5	1905	1910	1919	10	1931	1936
P	GA	-	-	1915	1918	13	1938	-
P	GA	-	-	-	1915	-	-	1918
D9S	AL171	-	-	1920	1922	9	1331	-
727	EA844	E4	1911	-	1921	-	1923	1930

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
P	GA	-	-	1925	1928	3	1931	-
J	GA	G1	1925	1930	1939	-	1941	1946
J	GA	G3	1925	1930	1939	3	1944	1949
B11	AL480	A2	1923	-	1933	-	1934	1942
J	GA	G4	1925	-	1935	-	1936	1944
J	GA	G5	1930	-	1940	-	1941	1949
D95	AL6	-	-	-	1943	-	-	1945
D95	AL29	A1	1940	1945	1954	-	1956	2001
P	GA	-	-	-	1945	-	-	1948
J	GA	G2	1935	-	1945	-	1946	1954
727	EA582	E1	1935	-	1945	2	1949	1956
J	GA	G6	1940	-	1950	-	1951	1959
D9S	EA2120	E2	1944	-	1954	-	1955	2003
J	GA	G1	1955	2000	2009	-	2011	2016
J	GA	G3	1955	2000	2009	3	2014	2019
J	GA	G4	1955	2000	2009	6	2017	2022
D9S	EA1131	E3	1955	2000	2009	9	2020	2025
P	GA	-	-	-	2000	-	-	2003
P	GA	-	-	-	2000	-	-	2003
J	GA	G5	1955	-	2005	-	2006	2014
D9S	AL194	-	-	-	2011	-	-	2013
J	GA	G2	2005	-	2015	-	2016	2024
J	GA	G5	2015	2020	2029	-	2031	2036
B11	AL373	A1	2015	2020	2029	3	2034	2039
P	GA	-	-	-	2030	-	-	2033
P	GA	-	-	2035	2038	-	2038	-
P	GA	-	-	2035	2038	-	2038	-
P	GA	-	-	2045	2048	-	2048	-
D9S	AL116	-	-	-	2045	-	-	2047

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
J	GA	G1	2035	-	2045	-	2046	2054
D9S	EA2130	E1	2042	-	2052	-	2053	2101
D9S	EA606	E2	2047	-	2057	-	2058	2106
D9S	EA1141	E3	2055	2100	2109	-	2111	2116
D9S	AL191	A1	2055	2100	2109	3	2114	2119
727	EA46	E4	2050	-	2100	-	2101	2109
J	GA	G1	2055	-	2105	-	2106	2114
D9S	AL156	A2	2058	-	2108	-	2109	2117
727	EA128	E1	2103	-	2113	-	2115	2122
J	GA	G1	2115	2120	2129	-	2131	2136
P	GA	-	-	-	2120	-	-	2123
J	GA	G2	2115	-	2125	-	2126	2134
P	GA	-	-	2130	2133	-	2133	-
D9S	AL263	-	-	2130	2133	-	2133	-
L10	EA944	E2	2121	-	2131	-	2135	2141
D9S	AL112	-	-	-	2134	2	-	2138
P	GA	-	-	2145	2148	-	2148	-
D9S	AL246	A1	2136	-	2146	-	2147	2155
D9S	EA2140	E1	2138	-	2148	-	2149	2157
727	EA429	E2	2155	2200	2210	-	2212	2217
727	EA419	E3	2155	2200	2210	3	2215	2220
D9S	EA1151	E4	2155	2200	2209	7	2218	2223
72S	EA546	E1	2157	-	2207	-	2209	2216
72S	EA512	E5	2202	-	2212	-	2214	2221
J	GA	G1	2210	2215	2224	-	2226	2231
72S	EA917	E6	2215	2220	2230	-	2232	2237
P	GA	-	-	2240	2243	-	2243	-
D9S	AL90	-	-	-	2245	-	-	2247
D9S	EA2150	E1	2235	-	2245	-	2246	2254

TABLE F-12

SIMULATION OF OPERATIONS UNDER THE PROPOSED TOWING RULE (Cont'd.)

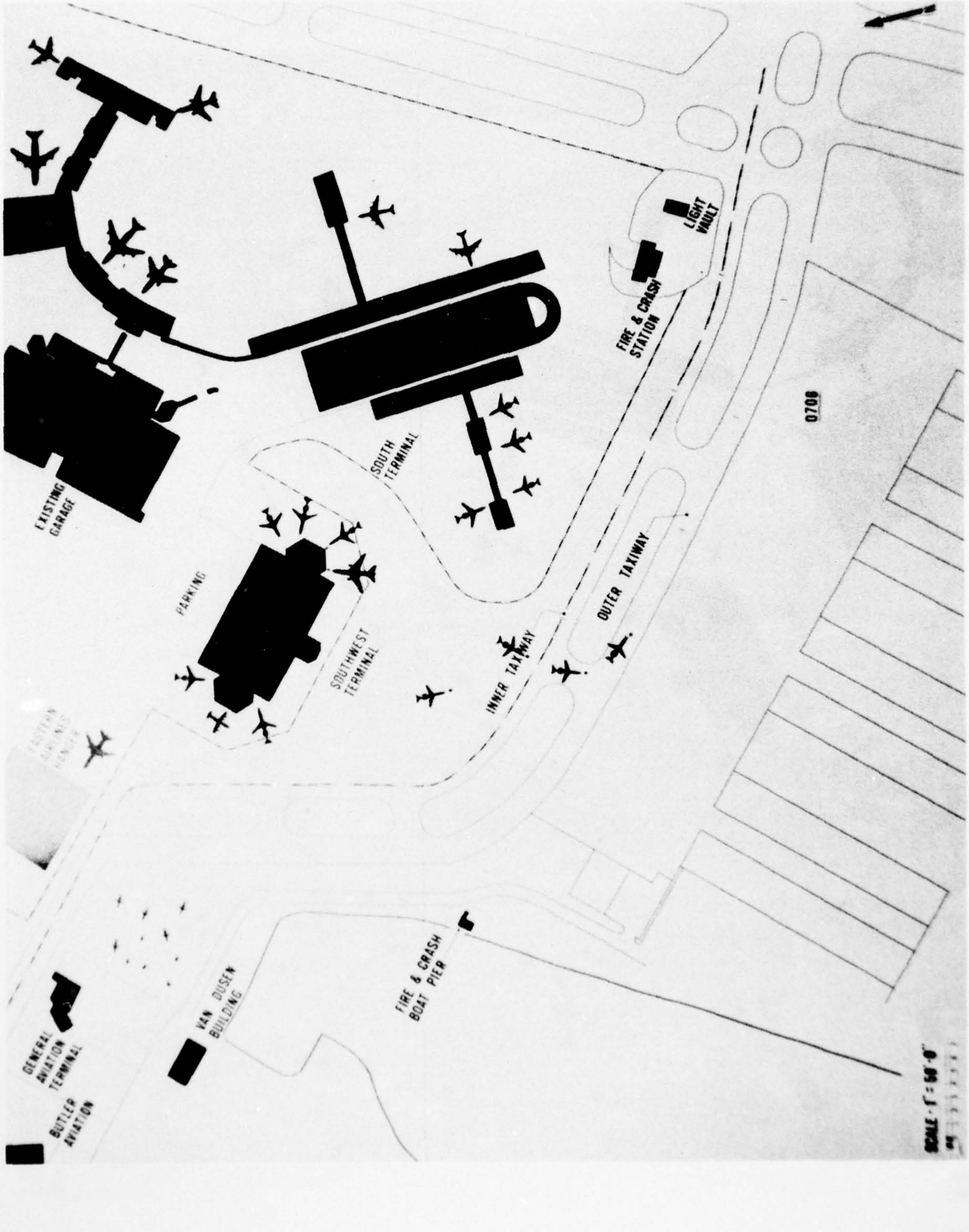
Aircraft	Flight No.	Tug No.	Time Tug Assigned	Tow Start Time	Aircraft at Firehouse	Queuing Delay	Tow or Taxi Start	Tug at Gate or ready to Reassign
D9S	AL296	A1	2247	-	2257	-	2258	2306
D9S	AL152	-	-	-	2300	-	-	2302
P	GA	-	-	-	2313	-	2313	-
B11	AL484	-	-	-	2310	-	-	2312
B11	AL438	A2	2303	-	2313	-	2314	2322
DC9	EA382	E1	2303	-	2313	2	2316	2324
727	EA608	E2	2310	-	2320	-	2322	2329
P	GA	-	-	2330	2333	-	2333	-
J	GA	G1	2325	2330	2339	-	2341	2346
P	GA	-	-	-	2335	-	-	2338
J	GA	G2	2325	-	2335	-	2336	2344
727	EA56	E1	2331	-	2341	-	2343	2350
P	GA	-	-	-	2355	-	-	2358
727	EA68	E2	2347	-	2357	-	2359	0006

TABLE F-13

SEQUENCE #1 OUTBOUND UNDER PROPOSAL RULE 0705-0738

TIME	TOW AL B11	TOW EA DC9	TOW EA 727	TOW AL B11	POWER AL DC9	TOW EA DC9	TOW EA 727	TOW AL DC9	POWER AL DC9	TOW EA DC9	TOW EA DC9	POWER GA Prop	POWER AL DC9
0705	2000	2325	2650	3000									
0706	1500	1825	2150	2500									
0707	1000	1325	1650	2000									
0708	500	825	1150	1500									
0709	0	325	650	1000	1700								
0710	0	325	650	1000	1325								
0711	0	325	650	1000	1325								
0712	-	0	325	675	1000								
0713	-	0	325	675	1000								
0714	-	0	325	675	1000								
0715	-	-	0	325	650	2000	2325						
0716	-	-	0	325	650	1500	1825						
0717	-	-	0	325	650	1000	1325	2000					
0718	-	-	-	0	325	650	975	1500					
0719	-	-	-	0	325	650	975	1300					
0720	-	-	-	0	325	650	975	1300					
0721	-	-	-	-	-	0	575	925	1700				
0722	-	-	-	-	-	0	325	675	1000				
0723	-	-	-	-	-	0	325	675	1000				
0724	-	-	-	-	-	-	0	350	675	2500	2825		
0725	-	-	-	-	-	-	0	350	675	2000	2325		
0726	-	-	-	-	-	-	0	350	675	1500	1825		
0727	-	-	-	-	-	-	-	0	325	1000	1325	1700	
0728	-	-	-	-	-	-	-	0	325	650	975	1300	2000
0729	-	-	-	-	-	-	-	0	325	650	975	1300	1625
0730	-	-	-	-	-	-	-	-	-	0	475	800	1125
0731	-	-	-	-	-	-	-	-	-	0	325	650	975
0732	-	-	-	-	-	-	-	-	-	0	325	650	975
0733	-	-	-	-	-	-	-	-	-	-	0	325	650
0734	-	-	-	-	-	-	-	-	-	-	0	325	650
0735	-	-	-	-	-	-	-	-	-	-	0	325	650
0736											-	-	0
Delay (min)	0	3	5	9	9	2	4	5	7	1	4	7	4

Source: GRA



EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
LIGHT VAULT
GENERAL AVIATION TERMINAL
BUTLER AVIATION
VAN DUSEN BUILDING
FIRE & CRASH BOAT PIER

Figure F-1

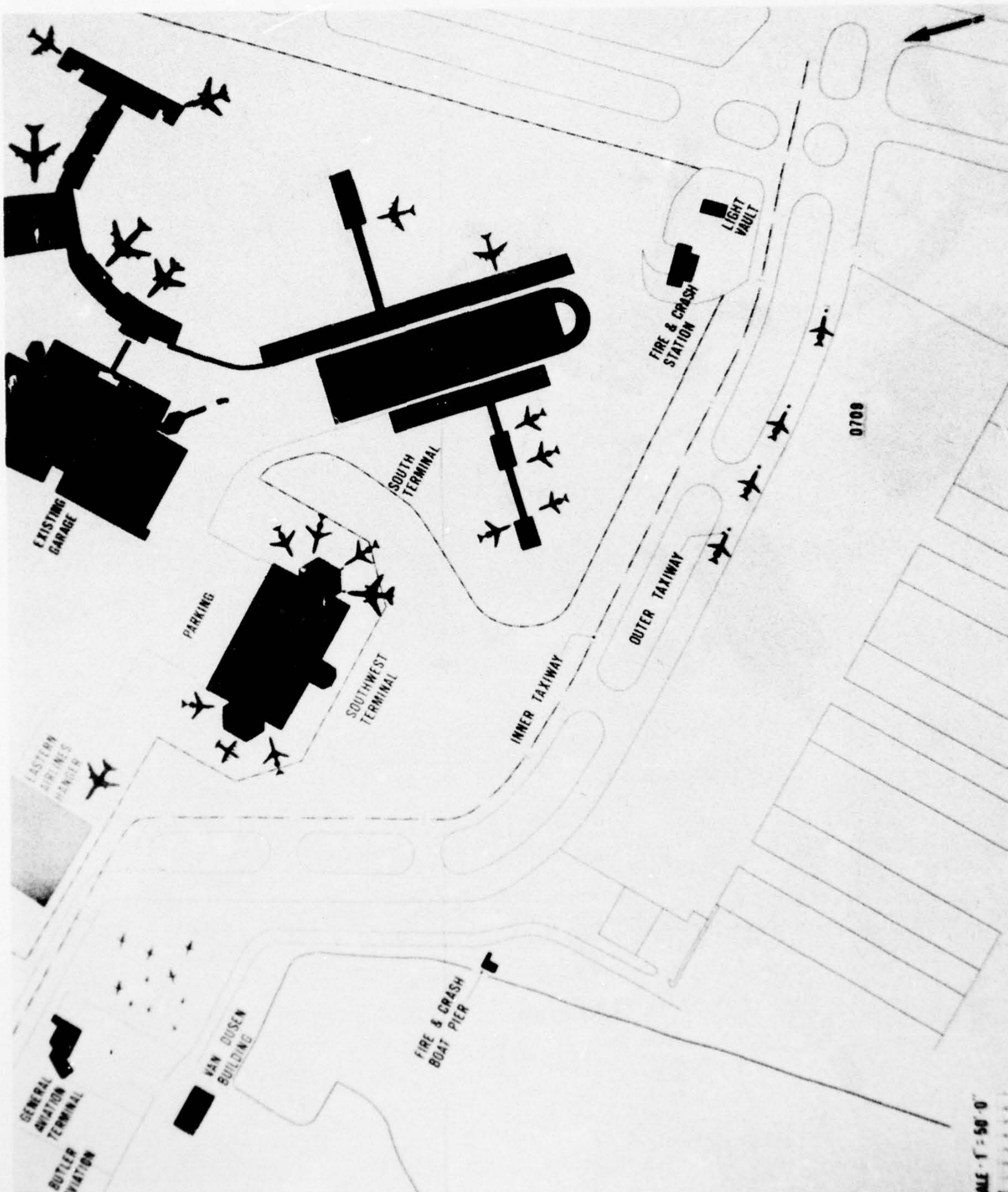
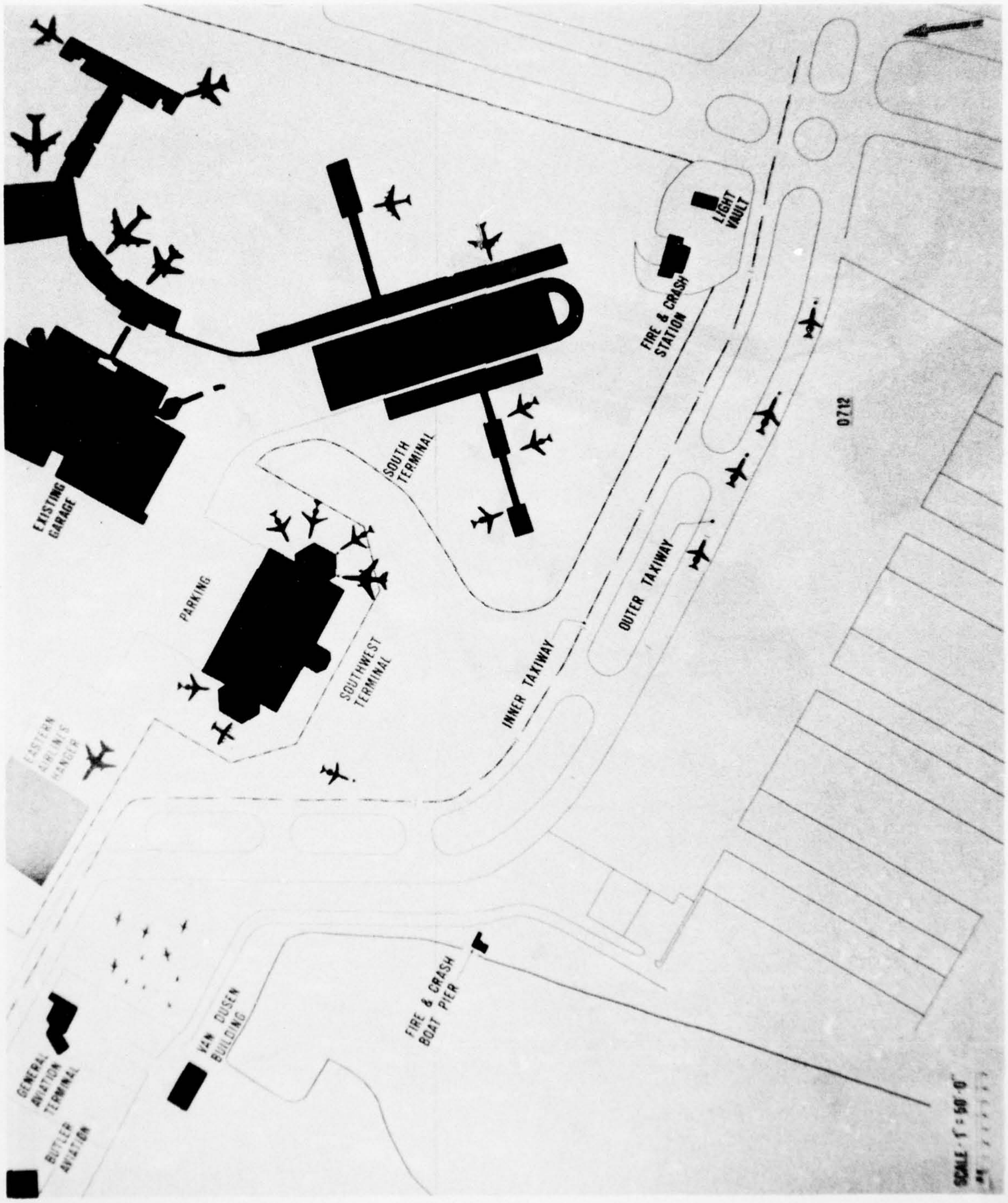

LIGHT VAULT
FIRE & CRASH STATION
SOUTH TERMINAL
EXISTING GARAGE
PARKING
SOUTHWEST TERMINAL
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE: 1" = 50'0"

Figure F-2

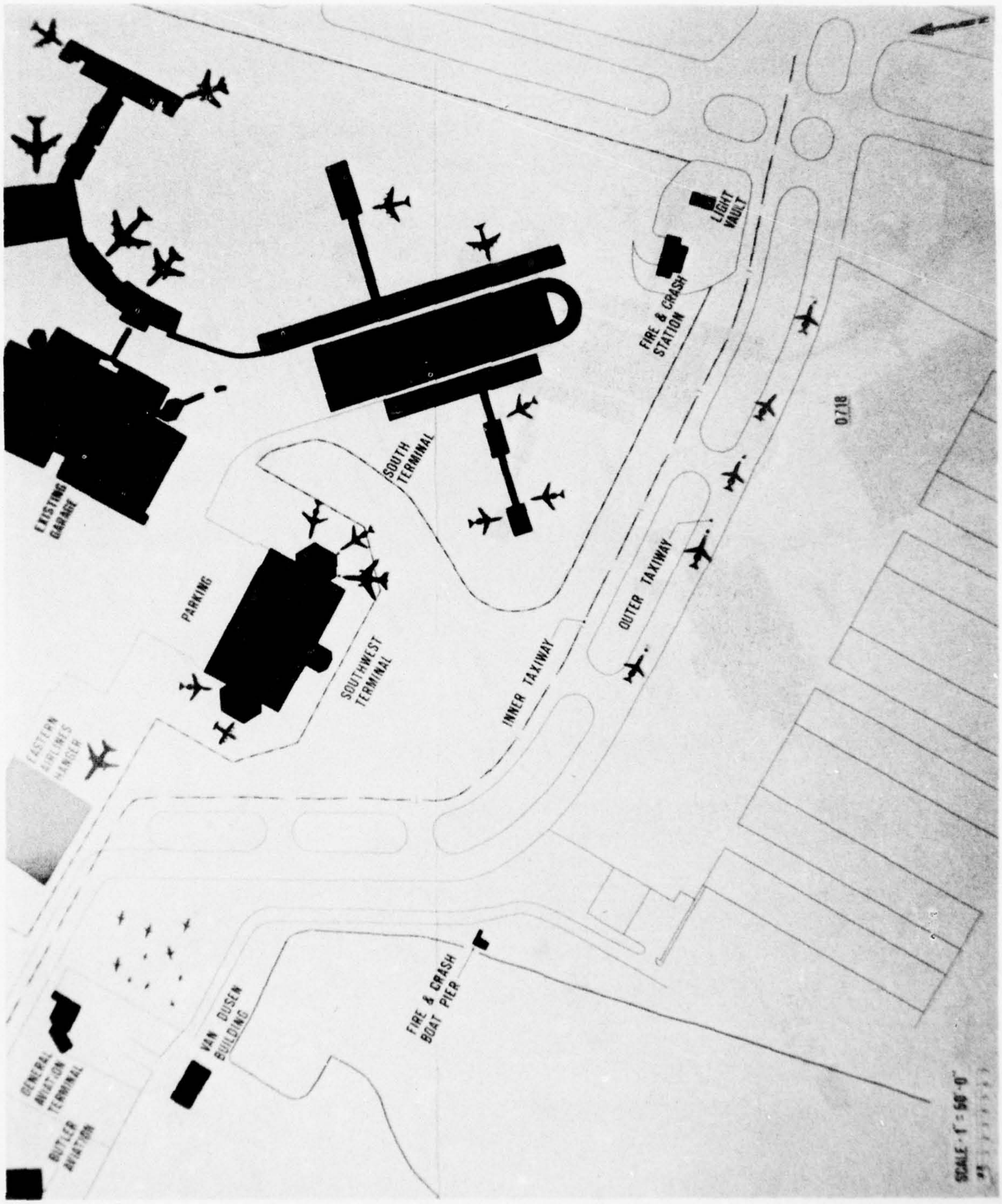


EXISTING GARAGE
SOUTH TERMINAL
PARKING
SOUTHWEST TERMINAL
EASTERN AIRLINES HANGER
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
LIGHT VAULT
0712
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE 1" = 50'-0"

Figure F-3


LIGHT VAULT
FIRE & CRASH STATION
0715
SOUTH TERMINAL
EXISTING GARAGE
PARKING
OUTER TAXIWAY
INNER TAXIWAY
SOUTHWEST TERMINAL
EASTERN AIRLINES HANGER
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE - 1" = 50'-0"

Figure F-4



EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
EASTERN AIRLINES HANGER
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
LIGHT VAULT
0718
VAN DUSEN BUILDING
FIRE & CRASH BOAT PIER
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure F-5

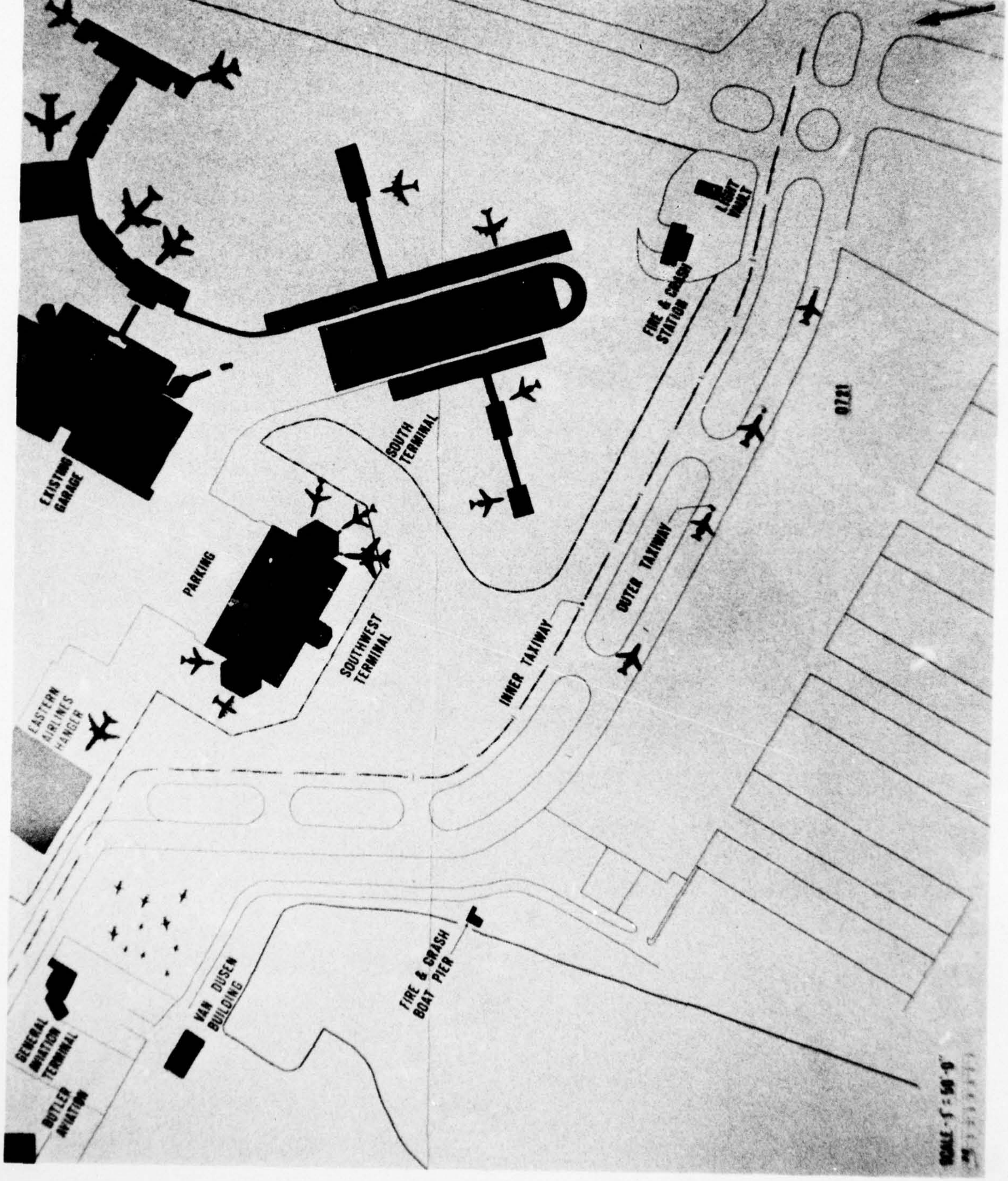
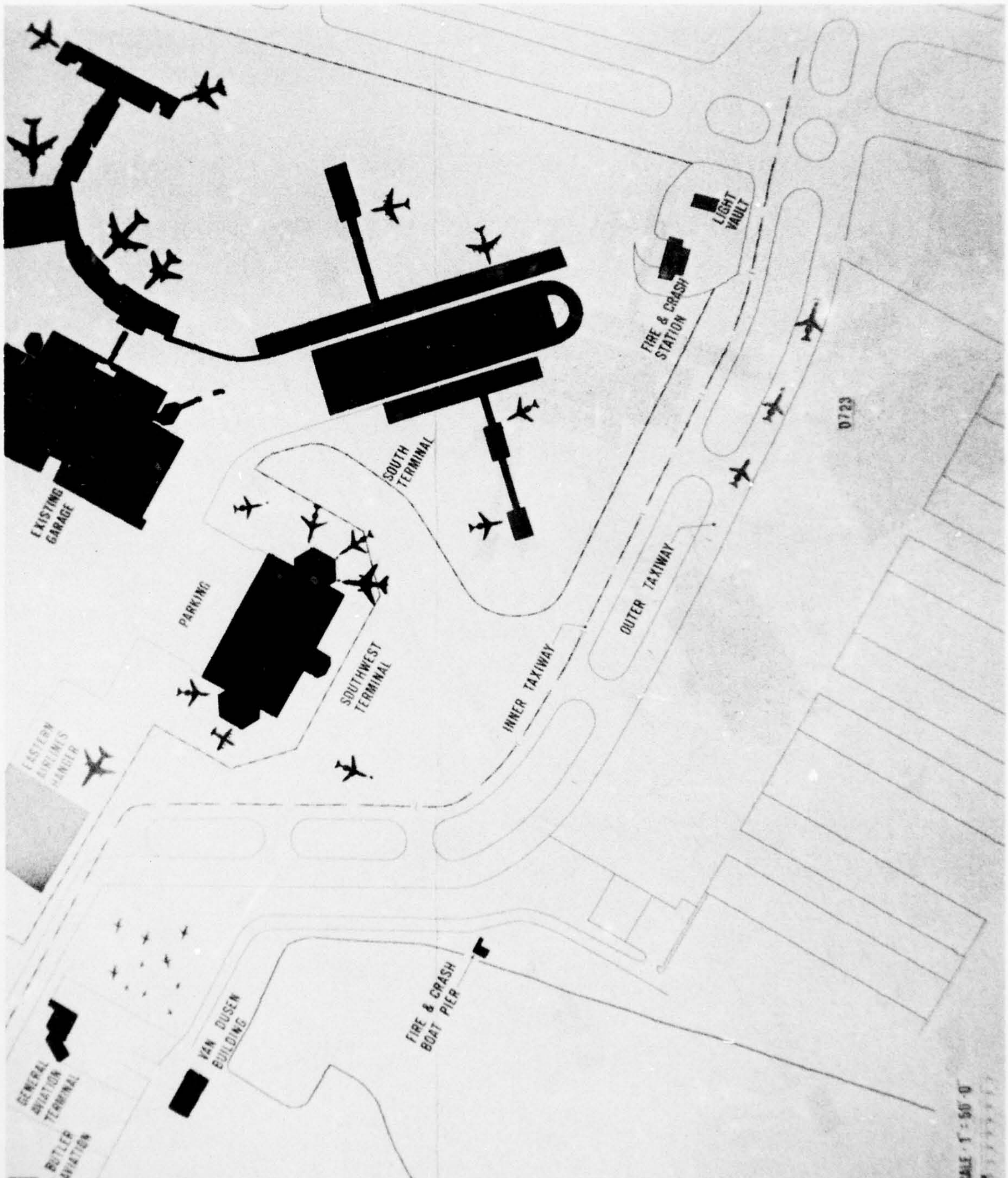

EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
EASTERN AIRLINES HANGER
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure F-6



EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
LIGHT VAULT
FIRE & CRASH STATION
INNER TAXIWAY
OUTER TAXIWAY
EASTERN AIRLINES HANGER
VAN DUSEN BUILDING
FIRE & CRASH BOAT PIER
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure F-7

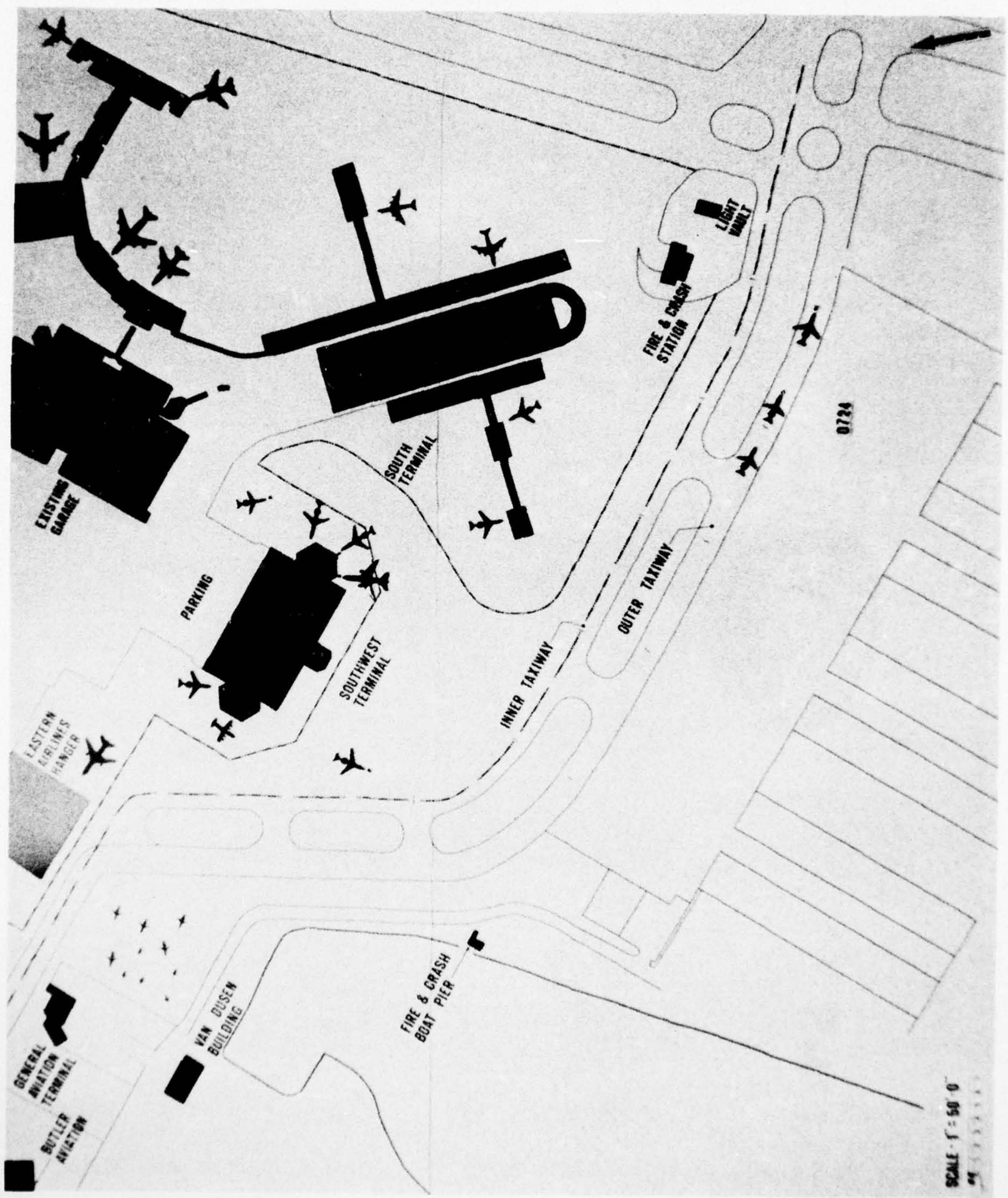

LIGHT VAULT
FIRE & CRASH STATION
SOUTH TERMINAL
EXISTING GARAGE
PARKING
SOUTHWEST TERMINAL
INNER TAXIWAY
OUTER TAXIWAY
0724
EASTERN AIRLINES HANGER
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE 1" = 50'-0"

Figure F-8

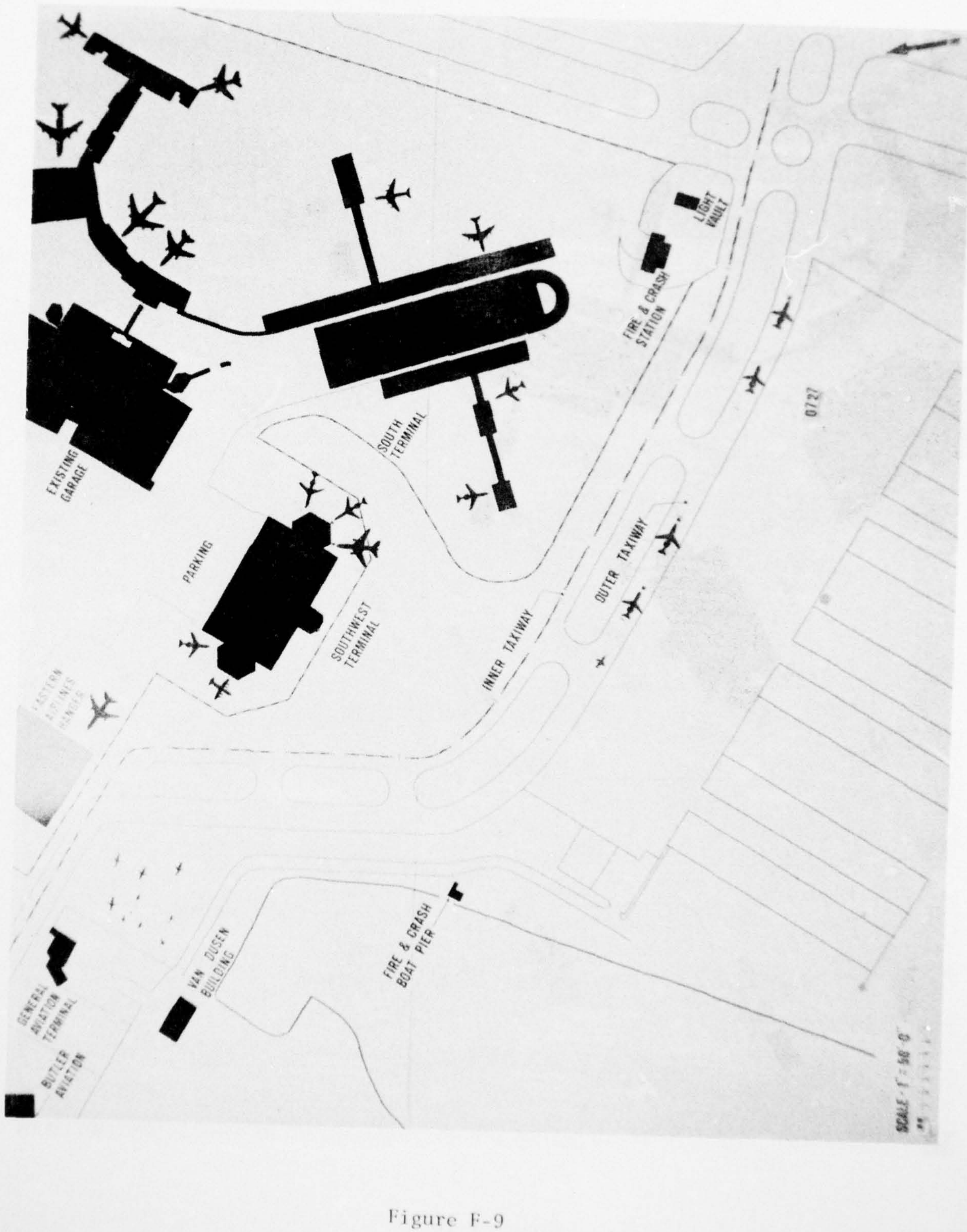

LIGHT VAULT
FIRE & CRASH STATION
SOUTH TERMINAL
EXISTING GARAGE
PARKING
SOUTHWEST TERMINAL
INNER TAXIWAY
OUTER TAXIWAY
0727
VAN DUSEN BUILDING
FIRE & CRASH BOAT PIER
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure F-9

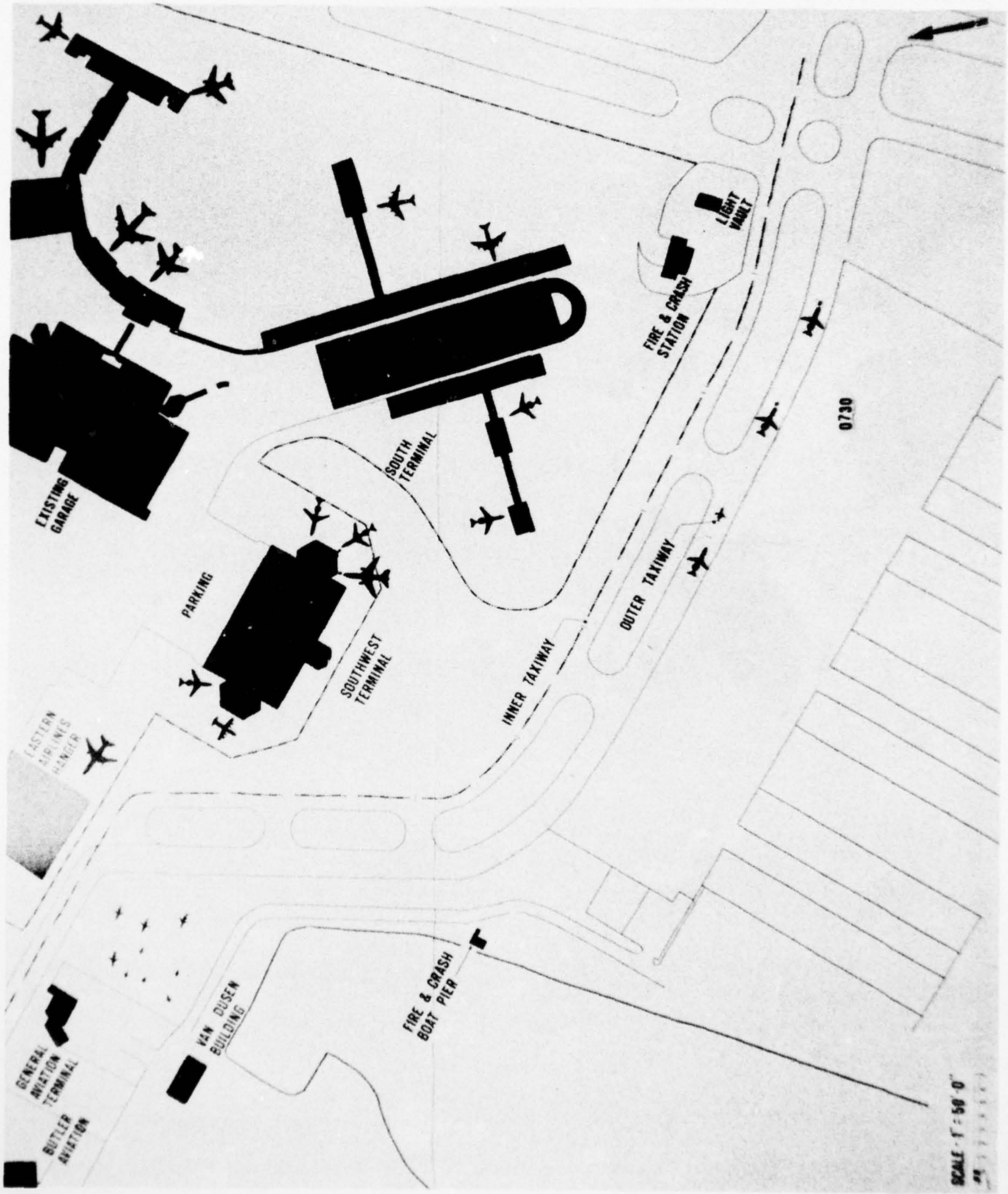

EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
EASTERN AIRLINES HANGER
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
LIGHT VAULT
0730
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE 1" = 50'-0"

Figure F-10

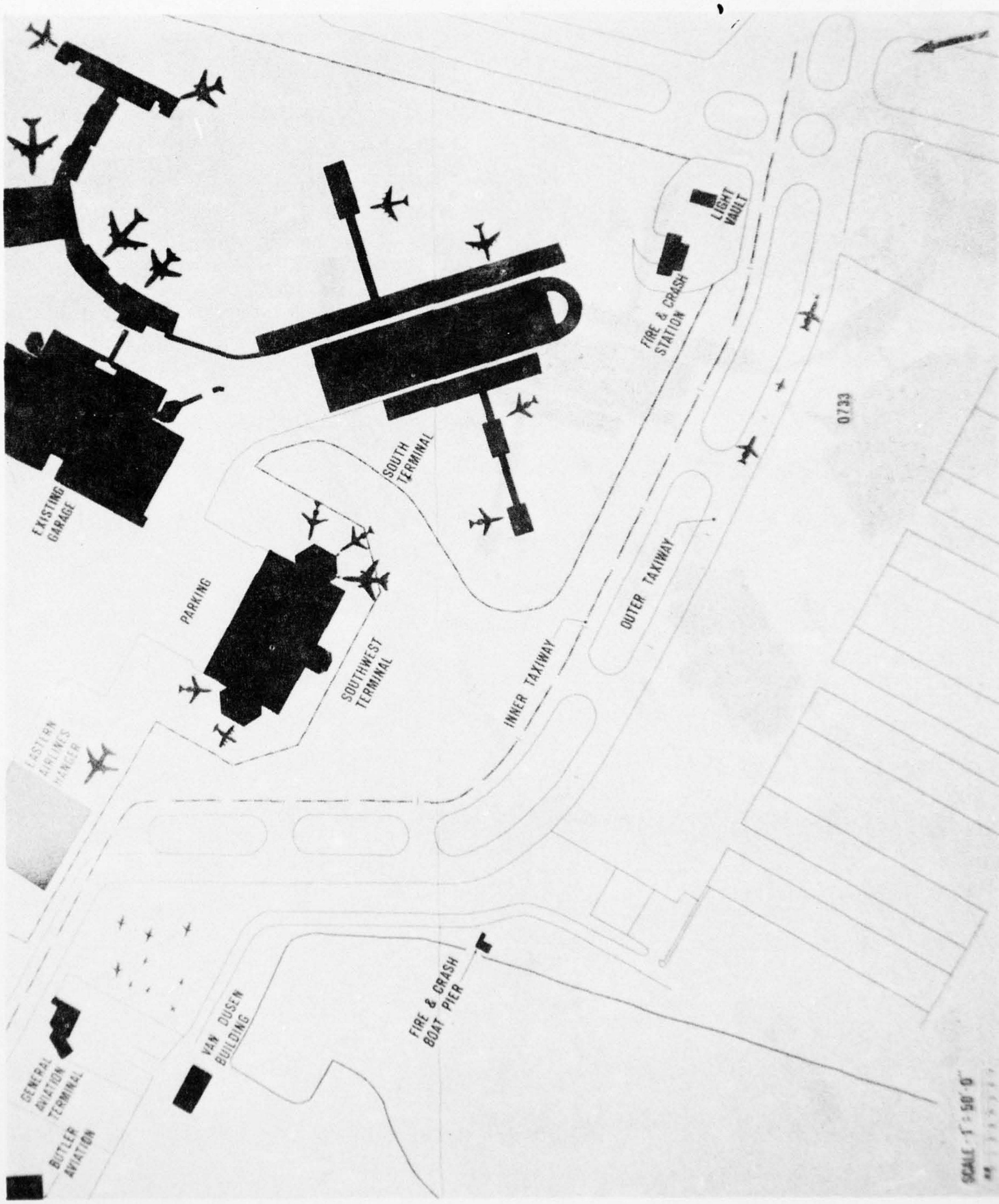
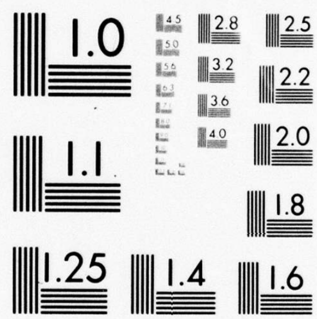

EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
EASTERN AIRLINES HANGER
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
LIGHT VAULT
0733
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION
SCALE-1"=50'-0"

Figure F-11

AD-A040 102 GELLMAN RESEARCH ASSOCIATES JENKINTOWN PA F/G 1/5
A STUDY OF AIRCRAFT TOWING AS PROPOSED FOR BOSTON-LOGAN INTERNA--ETC(U)
MAR 77 DOT-FA77WAI-728
UNCLASSIFIED FAA-AEQ-77-5 NL

3 OF 3
ADA040102

END
DATE
FILMED
6-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

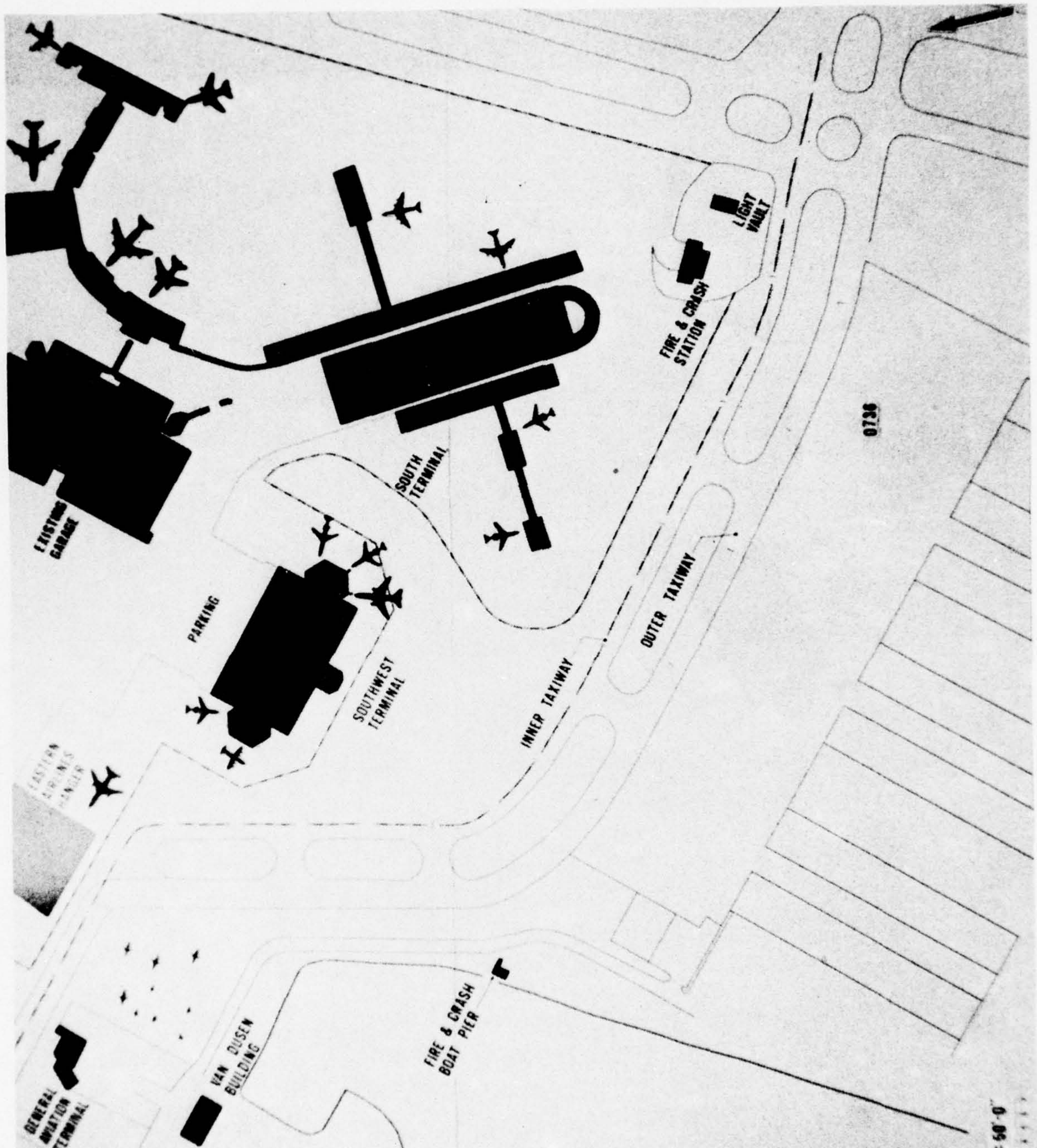

EXISTING GARAGE
PARKING
SOUTH TERMINAL
SOUTHWEST TERMINAL
INNER TAXIWAY
OUTER TAXIWAY
FIRE & CRASH STATION
LIGHT VAULT
0736
FIRE & CRASH BOAT PIER
VAN DUSEN BUILDING
GENERAL AVIATION TERMINAL
BUTLER AVIATION

Figure F-12

APPENDIX G

GATE HOLD PROCEDURES

BOSTON CONTROL TOWER

BOS TWR 7110.46

Nov. 10, 1976

Effective: Immediately

CONCURRENCES
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE
RTG. SYMBOL
INITIALS/SIG.
DATE

GATE HOLD PROCEDURES

I. PURPOSE: The purpose of this Order is to reinstate modified gate hold procedures for Boston Tower.

II. BACKGROUND: Our experience with the modified gate hold procedures for a 90 day evaluation period, dated April 16, 1976, indicates that the revised procedures were successful in reducing pilots' attempts to circumvent the procedure. Therefore, we are reinstituting these revised procedures locally and at the same time suggesting to Headquarters that they be adopted nationally.

III. ACTION:

A. When Gate Hold Procedures are in effect, the following message will be written on the telautograph and broadcasted on the ATIS:

"GATE HOLD PROCEDURES IN EFFECT, EXPECT APPROXIMATELY ____ MINUTE DELAY. CONTACT CLEARANCE DELIVERY FOR EXPECTED TAXI TIME."

B. When the aircraft calls for clearance, Clearance Delivery will instruct the aircraft to:

"EXPECT TAXI CLEARANCE AT (TIME), ADVISE READY TO TAXI ON 121.9."

C. The expected taxi time issued to the aircraft will be indicated in Box 15 of the flight progress strip.

D. If any aircraft does not meet his expected taxi time by plus or minus 5 minutes, he shall be put at the end of the pending departures and issued a revised taxi clearance.

E. The remaining procedures as contained in Chapter 1, Section 6, of Boston Tower Order 7110.35 remain unchanged.

WILLIAM C. KEEPERS

TRA, TWR, ANE-500, READ FILE

BOS-5:kw

FAA Form 1360-14 (7-67)

OFFICIAL FILE COPY

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

BOSTON CONTROL TOWER
Logan International Airport
East Boston, Massachusetts

LETTER TO AIRMEN 75-10

ISSUED: July 22, 1975 EFFECTIVE: Immediately

SUBJECT: GATE HOLD PROCEDURES

I. BACKGROUND: On November 23, 1973, Boston Tower implemented gate hold procedures which were designed to absorb much of the departure delay that an aircraft would experience prior to engine startup. These procedures were originally designed as an aid to the critical fuel situation. Although the fuel situation has slightly improved, it is still a major concern to all segments of the aviation industry.

Additionally, gate hold procedures eliminate a significant amount of aircraft noise and fuel emission problems for those communities surrounding the airport. Massport has erected Holding signs at the approach ends of various runways as an additional aid to limit the number of aircraft in the queue awaiting takeoff clearance.

Recently, some pilots have been ignoring the Hold instruction signs and also attempting to circumvent the procedures for holding aircraft at the gates. Frequently pilots will start engines prior to contacting Clearance Delivery. Additionally, some pilots are advising, whenever gate hold procedures are in effect, that they are ready to taxi, when in fact the aircraft has not even been completely loaded. Such actions are disruptive, to say the least, to the controller who is attempting to flow aircraft to the departure runway in an orderly fashion so that no delays result.

Therefore, we are re-issuing the gate hold procedures and request again the cooperation of all pilots utilizing Logan International Airport in order to reduce both fuel consumption for the industry and noise and emission problems for our neighbors.

II. GATE HOLD PROCEDURES:

A. The ATIS message will include the following messages:

"Gate hold procedures in effect. Expect approximately ( ) minute departure delay. Contact Clearance Delivery prior to engine start."

B. Clearance Delivery will, at the time aircraft call for clearances, advise all aircraft as follows:

"Expect ( ) minute delay. Advise on this frequency for engine start approval."

C. When an aircraft has been loaded and is ready for either taxi or pushback authorization, the pilot is requested to notify Clearance Delivery that he is ready to start engines. Clearance Delivery will instruct the aircraft to, "expect engine start at (time)".

D. At the appropriate time (or prior to that time if applicable) Clearance Delivery will advise the aircraft, "Start engines, advise when ready to taxi on (frequency)".

E. Aircraft that are unable to transmit without engines running are requested to call the Tower via telephone for the best estimate of anticipated engine start time. These aircraft may then start engines without further clearance and advise Ground Control when ready to taxi.

III. GENERAL: It will be the responsibility of the airline company concerned as to the priorities whenever an arriving aircraft has been assigned a gate at which a departure aircraft is being held. In this case, Boston Tower will approve engine start prior to the assigned engine startup sequence time; however, under no circumstances will the actual departure sequence be changed to accommodate this aircraft. The departing aircraft will be instructed to proceed to a holding area until such time as his normal departure sequence occurs.

If the delay changes, Clearance Delivery will issue new proposed engine start times; therefore, constant monitoring of the Clearance Delivery frequency once the clearance has been received will be mandatory.

Hopefully, with the cooperation of everyone concerned, these procedures will significantly reduce the quantity of aviation fuel consumed and aid in noise reduction to the surrounding communities.

This bulletin will remain in effect until cancelled.

William C. Keepers

WILLIAM C. KEEPERS
Chief, Boston Tower

APPENDIX H

EASTERN AIRLINES ESTIMATES OF COST IMPACT OF PROPOSED TOWING RULE

interoffice correspondence

EASTERN

TO:	Mr. R. E. Creswell	ADDRESS:	MIAMX
FROM:	J. W. Boyes	ADDRESS:	MIASS
SUBJECT:	Boston Towing Operation	DATE:	January 24, 1977

We have evaluated the impact of the towing operation in Boston with the current schedule, and find it will take six (6) additional ramp servicemen in Sales and Services.

There will also be a need for two (2) Bronco-type vehicles with radio equipment, needed to perform the operation.

If we can be of further assistance, call us at 6178.

J. W. Boyes

JWB:ms
cc: Messrs. R. N. Gault
D. P. Martin
F. M. Yaman

interoffice correspondence EASTERN

TO: Mr. R. E. Creswell ADDRESS: MIAMX

FROM: Hannibal M. Cox, Jr. ADDRESS: MIAEY

SUBJECT: Boston Towing Operation DATE: January 24, 1977

Reference: Your memorandum, dated January 17, 1977, same subject

Utilizing the new parameters you provided in the reference and in verbal instruction to Mr. D. E. Couts of my staff, the impact of the Boston towing operation on Ground Equipment would be as follows:

Increased Manning	2 mechanics
Increased Annual Parts Cost	$45,433.84
Increased Annual Labor Cost	$58,364.80
Purchase (1) T500 Tractor Cost	$164,000.00
Purchase (4) T300 Tractors Cost	$296,000.00
Purchase (1) Twin Air Start Cost	$88,000.00
Purchase (6) Aircraft Tow Bars Cost	$12,000.00

Work sheets showing detail calculations are attached for your reference.

Hannibal

Hannibal M. Cox, Jr.

HMC:CFN:a

Attachments

BOSTON
TOW-IN/OUT
EXERCISE

DEC 1/21/77

CRITERIA: - TRACTOR WILL BE IN POSITION 5 MINUTES BEFORE NEEDED.

- DEADHEAD FROM TERMINAL WILL COMMENCE 10 MINUTES BEFORE SCHEDULED ARRIVAL (5 MINUTES DEADHEAD + 5 MINUTES READINESS).

- ON TOW-OUT, THE MECHANIC(S) AND TRACTOR ARE TIED TO AIRCRAFT UNTIL START OF TAXI FOR DISCONNECT & ENGINE START.

- PREVAILING WIND (80%) ADDS 1:30 MINUTES TO TOW OUT OF B-3 & L-1011; NO EFFECT ON DC. (AIRCRAFT MUST BE TURNED INTO WIND FOR ENG. START)

- TOW OUT = SCHEDULED DPTR to START OF TAXI

DC-9 AVG 10:43 (MIN. 9-MAX 13)
B-727 AVG 12:40 + 1:30 (WWD) = 14:10 (MIN 7-MAX 19 ⊗)
L-1011 AVG 23:00 + 1:30 (WWD) = 24:30 (MIN 18-MAX 27 ⊗)
⊗ WAIT FOR CLRNC TO TOW

- TOW IN = SCHEDULED ARVL TO TIME AT GATE

DC-9 AVG 9:30 (MIN 9 - MAX 10)
B727 AVG 9:12 (MIN 8 - MAX 11)
L-1011 AVG 10:15 (MIN 9 - MAX 12)

- TIMES ASSIGNED:

EQUIP	TOW OUT	TOW-IN	TRACTOR DEADHEAD	TOW BAR EXCH
D-9	11	10	5	1
B-727	15	10	5	1
L-1011	25	11	5	1

- FLIGHT ACTIVITY

SCHEDULED	39
SHUTTLE	16
• EXTRA SCT.	14
	69

BEST AVAILABLE COPY

BEST AVAILABLE COPY

LEC 1/31/77

BOSTON TOW-IN/TOW-OUT SUMMARY (1)

TRACTOR	DEPARTURES D-9 # P/O	D-9 MINS @	B-3 # P/O	B-3 MINS @	L-1 # P/O	L-1 MINS @	D/H #	D/H MINS @	ARRIVALS D-9 # P/O	D-9 MINS @	B-3 # P/O	B-3 MINS @	L-1 # P/O	L-1 MINS @	D/H #	D/H MINS @	MINUTES UTILIZ.
# 1	3	16	11	20	0		11	5	4	15	12	15	0		10	5	
ELAPSED TIME		48		220				55		60		180				50	613
# 2	8	16	4	20	2	30	8	5	5	15	3	15	2	16	5	5	T500
ELAPSED TIME		128		80		60		40		75		45		32		25	485
# 3	11	16	1	20	0		3	5	12	15	3	15	0		4	5	
ELAPSED TIME		176		20				15		180		45				20	456
# 4	4	16	5	20	0		4	5	5	15	7	15	0		5	5	
ELAPSED TIME		64		100				20		75		105				25	389
# 5	4	16	7	20	0		8	5	6	15	3	15	0		3	5	
ELAPSED TIME		64		140				40		90		45	0			15	394
# 6	6	16	3	20	0		12	5	2	15	3	15	0		0		
ELAPSED TIME		96		60				60		30		45					291
# 7									2	15					2	5	
ELAPSED TIME										30						10	40
PRESTAGE TOW-OUT		5 + 11		5 + 15		5 + 25				5 + 10		5 + 10		5 + 11			
ELAPSED TIME		16		22		30				15		15		16			

(1) ASSUMES TOW BARS MAY NOT BE STORED AT MIDFIELD

(BOSTON MANNING)

	[NEW UTILIZATION REQUIREMENTS PER MONTH]	− [OLD UTILIZATION REQUIREMENTS PER MONTH]	= [TOTAL INCREASED UTILIZATION REQUIREMENTS]	÷ 100 [MANNING STANDARD]	= [MAINTENANCE MAN HOURS REQ'D.]
T-300	1091.5	262.0	829.5	20.97	173.9
T-500	242.5	94.0	148.5	15.85	23.5
GENERATORS	801.5	61.0	740.5	5.33	39.4
TWIN AIR	94.0	59.0	35.0	6.54	2.2

SUB-TOTAL MANHOURS REQ'D. = 239.2

26.4% INDIRECT LABOR = 63.1

13% VAC/SICK/COVERAGE = 39.3

TOTAL MANHOURS REQ'D = 341.72

EQUIV. MECHS. = 1.97

(SAY 2.00)

ANNUAL INCREASED LABOR COST:
(2 MECHS) x (2080 MH/YR) x ($14.03/HR) = $58,364.80

$9.56 AVG HOURLY WAGE
\+ 46.8% BENEFITS (R. RAWLS LETTER 2/11/76)

$14.03 PER HR. INCLUDING BURDEN

BOSTON
STUDY
1-24-77
NORRIS

BEST AVAILABLE COPY

BOSTON STUDY

1-24-77

ANNUAL PARTS COST INCREASE:

	INCR. UTIL.	x	COST/HR	x	.45	x	12 MONTHS	=	TOTAL
T-300	829.5		$6.06		.45		12		= $27,144.56
T-500	148.5		$5.67		.45		12		= $ 4,546.77
GENERATORS	740.5		$3.32		.45		12		= $13,275.68
TWIN AIR	35.0		$2.47		.45		12		= $ 466.83

TOTAL = $ 45,433.84

NOTE (.45) = 45% OF. COST/HR FIGURE IS PARTS COST.

SCHEDULE EFFECTIVE: 77-02-14 CHANGE PAGE:
MSNC NBR: DC-C4 VERSION NBR:
FLOW DATE: 77-02-14

STATION ACTIVITY LISTING
*** PCS ***

SDS15CF2
PAGE 22
PUN DATE: 76-12-03

ARRIVALS EFF DATE	DISC DATE	FREQUENCY MTWTFSS	3RD STN	2ND STN	PRE STN	STF NBR	FLT REF	EC	ARVL TIME	GRND TIME	DEPARTURES DPTR TIME	EQ	FLT NBR	NXT STN	2ND STN	3RD STN	FREQUENCY MTWTFSS	EFF DATE	DISC DATE	MEALS	STS
			GSP	CLT	PHL	3	608	CF	2320	6:40	0600		379	PHL	CLT	CHS				EE	98
			ATL	RDU	DCA	4	512	S3	2212	7:48	0600		869	BDL	DCA	PBI					137
			FLL	ATL	PVD	3	546	S3	2207	8:30	0637		727	PVD	ATL	FLL					137
			553	MSY	LGA	2	68	CF	2357	7:03	0700		517	EWR	559					EE	98
											0700	SF	1011	LGA	1020		MTWTF..				107
			133	IAH	EWR	2	56	B3	2341	7:29	0710		69	LGA	MSY	62				EE	107
			TPA	MCO	BDL	3	382	S9	2313	8:07	0720		145	ATL	DFW	529				EE	67
			EVV	SDF	EWR	5	616	S9	2157	10:23	0720		377	DCA	FDU	568				EE	92
				47	MIA	1	418	F3	0052	6:43	0735		187	BDL	TPA	312					107
		MTWTF..		1530	LGA	1	1160	SH	0742												
770215	770221		DAB	ATL	PHL	3	114	CF	0142	6:18	0800		665	EWR	SRQ	332				EE	98
		MTWTF.S		1121	LGA	1	1140	SH	2130	10:12	0800		1011	LGA	1030		MTWTFS.				107
				949	SJU	1	944	LL	2131	10:59	0820		601	MCO	870					PP	268
770215	770221		JAX	ATL	PHL	4	486	S2	0337	5:03	0840		867	PHI	558					PP	137
		MTWTFS.		1141	LGA	1	1010	SH	0952												
				406	EWR	1	528	L3	0754	1:06	0900		41	MIA	18					PP	137
											0900	SF	1021	LGA	1040						107
			721	MIA	ATL	2	582	P3	1945	12:25	0910		861	FLL	MIA	42				PP	107
				294	EWR	1	536	S9	0642	:48	0930		869	DCA	JAX	DAB					92
				661	MCO	1	604	LL	1800	16:00	1000		945	SJU	952					LL	268
											1000	SF	1031	LGA	1050						107
			754	RDU	DCA	2	398	CF	0930	:50	1020		145	ATL	MSY	60				LL	98
			435	ATL	CLT	2	650	S9	0948	:52	1040		567	EWR	RIC	ATL					92
			571	RIC	EWR	2	562	B3	1004	:51	1055		57	EWR	IAH	52					107
				1001	LGA	1	1020	SH	0954	1:06	1100		1041	LGA	1060						107
			7187	PBI	TPA	2	178	B3	1059	:51	1150		133	DCA	ATL	IAH				SS	107
				1011	LGA	1	1030	SH	1050	1:10	1200		1051	LGA	1070						107
											1220	B2 OP	845	FLL	4444		......S. ....S			LL	107 98
			447	DAB	ATL	2	148	E3	1130	:49	1227		179	TPA	272					LL	107
			DAB	JAX	DCA	4	878	S9	1149	:49	1228		533	ATL	MSY	558				LL	92
				1021	LGA	1	1040	SH	1148	1:12	1300		1061	LGA	1080						107
				1031	LGA	1	1050	SH	1249	1:11	1400		1071	LGA	1090						107
			551	IAH	EWR	2	54	CF	1315	:50	1405		383	EWR	CLT	GSP					98
				889	PBI	1	868	S3	1402	:58	1500		549	DCA	PDU	ATL				S	137
				1041	LGA	1	1060	SH	1349	1:11	1500		1081	LGA	1100						107

interoffice correspondence

EASTERN

TO: Mr. R. E. Creswell — ADDRESS: MIAMX

FROM: A. B. Burnside — ADDRESS: MIAMU

SUBJECT: Boston Towing Operation — DATE: January 26, 1977

Reference: Your memorandum dated January 17, 1977, same subject

Per your request, summarized below is an analysis of the expense impact on Aircraft Maintenance resulting from towing requirements of the Massport Noise Regulation, commencing January 1, 1978.

- o Additional Personnel Requirement:

  (a) Tow Crews - 13 (Three Man Crews, plus two for vacation relief) = 41

- o Cost of Additional Personnel:

  (a) 41 Mechanics X 2086 M/Hrs. = 85,527 Total Additional Man-Hours.

  (b) 1978 Hourly Rate:

Wage Base	-	\$10.42000
Benefit Rate	-	1.65992
Total Hourly Rate		\$12.07992

  (c) Total Hourly Wages--85,527 Hours X \$12,07992 = \$1,033,159.

- o Fuel Cost Increase--Ground Service Equipment:

Equipment	Utilization/Year	Per Hour Fuel Consumption	Total Fuel Consumption
T-300	9954 Hours	14 Gal.	139,356 Gal.
T-500	1782 Hours	18 Gal.	32,076 Gal.
Generators	8886 Hours	7 Gal.	62,202 Gal.
Twin Air	420 Hours	16 Gal.	6,720 Gal.
		Total:	240,354 Gal.
			X .3633
			\$87,321

A. B. Burnside

cc: Mr. H. H. Andreas
Mr. G. W. Hardy
Mr. W. E. Loucks

C.(3) COST ANALYSIS OF AIRCRAFT OPERATIONS MOVEMENT

TOWING REGULATION

BOSTON LOGAN AIRPORT

	Non-Recurring Costs
I. Additional Ground Support Equipment	
A. Tow Tractors:	
1. T-500	1
2. T-300	4
B. Ground Start Unit	1
C. Tow Bars	6
D. Tower Frequency Communication Equipment	15
E. 200 lb. Dry Chemical Fire Extinguishers	5
F. Econo-Line Vehicles	2
II. Cost of Ground Support Equipment	
A. Tow Tractors:	
1. T-500	$164,000
2. T-300	296,000
B. Ground Start Unit	88,000
C. Tow Bars	12,000
D. Communication Equipment	30,000
E. Fire Extinguishers	6,000
F. Econoline	12,000
TOTAL	$608,000

——Prepared By: A. Burnside
January 25, 1977

C. (2) COST ANALYSIS OF AIRCRAFT OPERATING MOVEMENT

TOWING REGULATION

BOSTON LOGAN AIRPORT

		Annual Recurring Costs
I.	**Additional Personnel Requirements**	
A.	Towing - Aircraft Maintenance Mechanics	41
B.	Equipment Maintenance - GSE Mechanics	2
C.	In-Flight Service - Flight Attendants	31
D.	Flight Operation - Pilots	23
E.	Sales and Service - Ramp Servicemen	6
	TOTAL	103
II.	**Annual Cost Of Additional Personnel**	
A.	Towing	$1,033,159
B.	Equipment Maintenance	58,365
C.	In-Flight Service	393,483
D.	Flight Operation	1,320,915
E.	Ramp Service	124,494
	TOTAL	$2,930,416
III.	**Additional Ground Support Equipment Cost**	
A.	Depreciation	
	1. T-500 Tractor	$ 27,333
	2. T-300 Tractor	49,333
	3. Ground Start Unit	14,667
	4. Tow Bars	2,000
	5. Communication Equipment	5,000
	6. Fire Extinguishers	1,000
	7. Econolines	2,000
	TOTAL	$ 101,333
B.	Material Expense	$ 45,434
IV.	**Flight Attendant Uniforms**	$ 13,950

		Annual Recurring Costs
V.	Loss of Aircraft Time (Profit Contribution)	$4,162,000
VI.	Fuel Costs (Reduction)/Increase	
	Aircraft Fuel	(26,258)
	GSE Fuel	87,321
	TOTAL RECURRING	$7,314,196

NOTE: Above costs based upon:

(A) MASSPORT Noise Regulation Article V, Paragraph C., Commencing January 1, 1978.

(B) EAL December 8, 1976 Operating Schedule (Appendix G)

Prepared by: A. Burnside
January 25, 1977

interoffice correspondence

EASTERN

TO:	Mr. Ray E. Creswell	ADDRESS:	MIAMX
FROM:	J. M. Jones	ADDRESS:	MIAFH
SUBJECT:	Boston Towing Operation	DATE:	January 21, 1977

Reference: Your January 17, 1977 memo of subject

Per your request, attached is In-Flight Services' analysis of the impact the proposed towing operation would have on our department in 1977, showing an estimated incremental flight attendant cost of $393,500 for the year.

If you have any questions regarding the attached, please call me on Miami extension 6166.

J. M. Jones

J. M. Jones
Manager,
Flight Attendant Planning

JMJ:jd

cc: T. L. Bookout
C. H. Buckland
H. M. Cox
E. S. Gilbert
D. S. Klein
M. H. Scott
T. B. Spratt

1/21/77

1977 INCREMENTAL COST IMPACT
OF BOSTON TOWING OPERATION
ON IN-FLIGHT SERVICES

Category	Annualized Incremental B/B Hours(1)		F/A Crew Complement(2)		Annualized Incremental F/A Weighted B/B Hours
System L-1011	256	X	10	=	2,560
System 727S	807	X	5	=	4,035
System B727	1,272	X	4	=	5,088
System D930	492	X	3	=	1,476
System D914	18	X	3	=	54
Prime A/S D9's	641 (3)	X	3	=	1,922
A/S Standby	1,664 (3)	X	3	=	4,992
Total Annual Incremental Flight Attendant Hours				=	20,127

1977 Incremental Flight Attendant Cost = 20,127 hours X $19.55/hour(4) = $393,483

NOTES:

(1) Source: Schedule Planning Department

(2) Estimated 1977 flight attendant crew complements required by new flight attendant contract

(3) Annualized incremental hours reduced by 50% for one-for-two on-duty credit impact

(4) Average 1977 flight attendant hourly effective cost, calculated as follows:

	$16.16	1/1/77 average F/A hourly incentive rate, applied due to additional utilization created per F/A
+	1.29	Estimated 8% 1977 contract escalation
	$17.45	
+	2.10	Estimated 12% average hourly benefits cost per F/A
	$19.55	

interoffice correspondence

EASTERN

TO: Mr. R. E. Creswell — ADDRESS: MIAMX

FROM: T. B. Spratt, Jr. — ADDRESS: MIAFX

SUBJECT: Massport — DATE: January 24, 1977

Ray, per your request, we have calculated the impact of the proposed towing operation at Boston.

The proposal will result in an increased pilot manning of 22.5 pilots at a total cost of $1,320,915, including salaries and benefits. This cost is slightly offset by a small fuel savings of $26,258 for a net increase in cost of $1,294,657 per year.

If you have any questions, please call me on extenstion 7088.

T. B. Spratt, Jr.

T. B. Spratt, Jr.

Attachment

cc: Messrs. W. R. Brady
T. R. Buttion
A. A. Cyr
H. E. Hibbe
D. S. Klein
J. R. Montalvo
W. E. Loucks
L. C. Transou

1/24/77

MASSPORT TAXI-TOW

COST IMPACT FLIGHT OPERATIONS

FLIGHT CREW MANNING

BLOCK HOUR VARIANCE (1)

EQUIPMENT	PILOTS
L-1011	+ .3
B-727	+6.6
DC-9	+4.2
	+11.1

A-S STANDBY

DC-9	+ 5.4

A-S 1:00 VS. :30 Turns

DC-9	+ 6.0
TOTAL	+22.5

ANNUAL COST

	(2)
Salaries	$ 1,054,200
Benefits	266,715
TOTAL	$ 1,320,915

AIRCRAFT FUEL

VOLUME VARIANCE

EQUIPMENT		GALLONS/YEAR
L-1011		-31,298
B-727		-24,931
DC-9		-20,774
	TOTAL	-77,003

ANNUAL REDUCTION

77,003 Gallons x $ .3410/Gallon (3) = $ 26,258

NET ANNUAL COST

Salaries and Benefits		$ 1,320,915
Fuel		- 26,258
	TOTAL	$ 1,294,657

(1) Based on block hours from Schedules Planning Department.
(2) April 1977 rates; no escalation for new contract.
(3) Current fuel price at Boston.

interoffice correspondence EASTERN

TO: Mr. R. F. Creswell ADDRESS: MIAMX

FROM: D. S. Klein ADDRESS: MIAKR

SUBJECT: Boston Towing Regulation - Aircraft Utilization Effect DATE: January 21, 1977

As requested, we have updated our estimate of the impact of towing on aircraft utilization, based on your final data. The effect of towing Shuttle aircraft remains at $2,100,000, as stated in my memorandum of January 11, to Bill Loucks. However, the effect of non-Shuttle towing has been revised as follows:

	Revised Block Hours Lost	Contribution per Block Hour	Revised Contribution Loss (000)
L-1011	256	$1,396	$ 357
B-727-200	807	826	667
B-727-100	1,272	549	698
DC-9-31	492	677	333
DC-9-14	18	380	7
Total	2,845		$2,062

Thus, the proposed towing regulation at Logan would cost $4,162,000 annually in lost aircraft utilization.

D. S. Klein

D. S. Klein

DSK:mj

cc: Mr. W. E. Loucks

APPENDIX I

TSC NOISE MEASUREMENTS AT LOGAN AIRPORT

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE
CAMBRIDGE, MA 02142

DATE: February 10, 1977

In reply refer to: TSC-331

SUBJECT: Aircraft Operations Noise Data At Logan Airport (PPA FP706 Environmental Quality Support)

FROM: Robert W. Quinn

TO: Edmund W. Sellman, AEQ-200

In response to your request, noise measurements were made near Logan Airport at a site on Neptune Road. Reduced data resulting from these measurements are enclosed and further explained below.

Figure 1 illustrates the airport area near the microphone site. The microphone was placed in a playground to the northeast of Neptune Road at the airport end approximately 40 ft. from the near edge of the street and 3 ft. from the airport property fence. Noise data was recorded on magnetic tape for periods of fifty minutes each. Four daytime measurements were made on January 19, 1977 between the hours of 9:30 and 13:30. Three nighttime measurements were made on January 26, 1977 between the hours of 21:00 and 24:00.

Tables 1 and 2 are tabulations of community noise statistical indexes.

Column headings are described as follows:

T - Time segment number
- 1 - first 10 minute segment
- 2 - second 10 minute segment
- 3, 4, 5, etc.
- 50 - the statistical indexes are calculated on the entire 50 minutes.

A - Arithmetic average of the 1/8th second samples (4,800 samples for 10 minutes, 24,000 samples for 50 minutes)

S - Standard Deviation of the 1/8th second samples

E - Energy Mean (average on an energy basis) of the 1/8th second samples.

N - Noise Pollution Level calculated using the energy mean and standard deviation.

M - Highest 1/8th second sample during the period T.

R - Range (Max. minus min.) of the 1/8th second samples during the period T.

1, 10, 50, 90 and 99 - L(x) = 1, 10, 50, 90 or 99.

L(x) - the noise level exceeded x percent of the time during period T.

These tables are arranged so that each 50 minutes is represented by one block of statistical data in the table. Each block lists the above indexes for each of the five contiguous ten minute segments followed by the same indexes for the full 50 minute period. Table 1 contains four blocks of data for the four daytime runs. Table 2 contains three blocks of data for the three nightime runs.

Tables 3, 4 and 5 are tabulated noise measurements of specific events, from airport operations and community activities that were noted during the measurement periods. A graphic level time history recording was prepared for each 50 minute measurement using an averaging time approximating the slow response of a sound level meter. The maximum noise level of each specific event was tabulated. Table 3 is a tabulation of aircraft departures using runways 33L. The tabulated values are the arithmetic average of the maximum noise levels measured. Table 4 is a tabulation of aircraft runup and taxi operations. The tabulated values are the maximum noise levels for each event. Table 5 is a tabulation of automobile and truck passbyes. The tabulated values are the arithmetic averages of maximum noise levels. Both the events descernable on the time history and those not discernable are counted, but only those discernable are used to calculate the average.

Figures 2, 3, 4 and 5 are graphic level time histories of selected taxi and runup operations. Figure 2 is a time history showing the noise generated by a turbo-prop aircraft running up and taxiing from the cargo area, behind some buildings and then past the international terminal and the north terminal. Figure 3 is a time history showing the noise generated by a 707 taxiing past the north terminal and parking at the international terminal on January 26, 1977 at about 23:15 hours. Figure 4 is a time history showing the noise generated by a DC-9 being towed from the north terminal area to the hangar near the cargo area on January 26, 1977 at approximately 23:30 hours.

Figure 5 is a time history showing two DC-9's taxiing from the north terminal area to the hangar near the cargo area on January 26, 1977 at approximately 23:45 hours.

Data reduction for the remaining two measurement sites is in process and will be reported one at a time as they are completed.

Robert W. Quinn

Robert W. Quinn
Environmental Technology Branch

Enclosures: 10 pages of data

cc:
TSC-331/E. Darling
TSC-331/E. Rickley
TST-53/J. E. Wesler

FIGURE 1

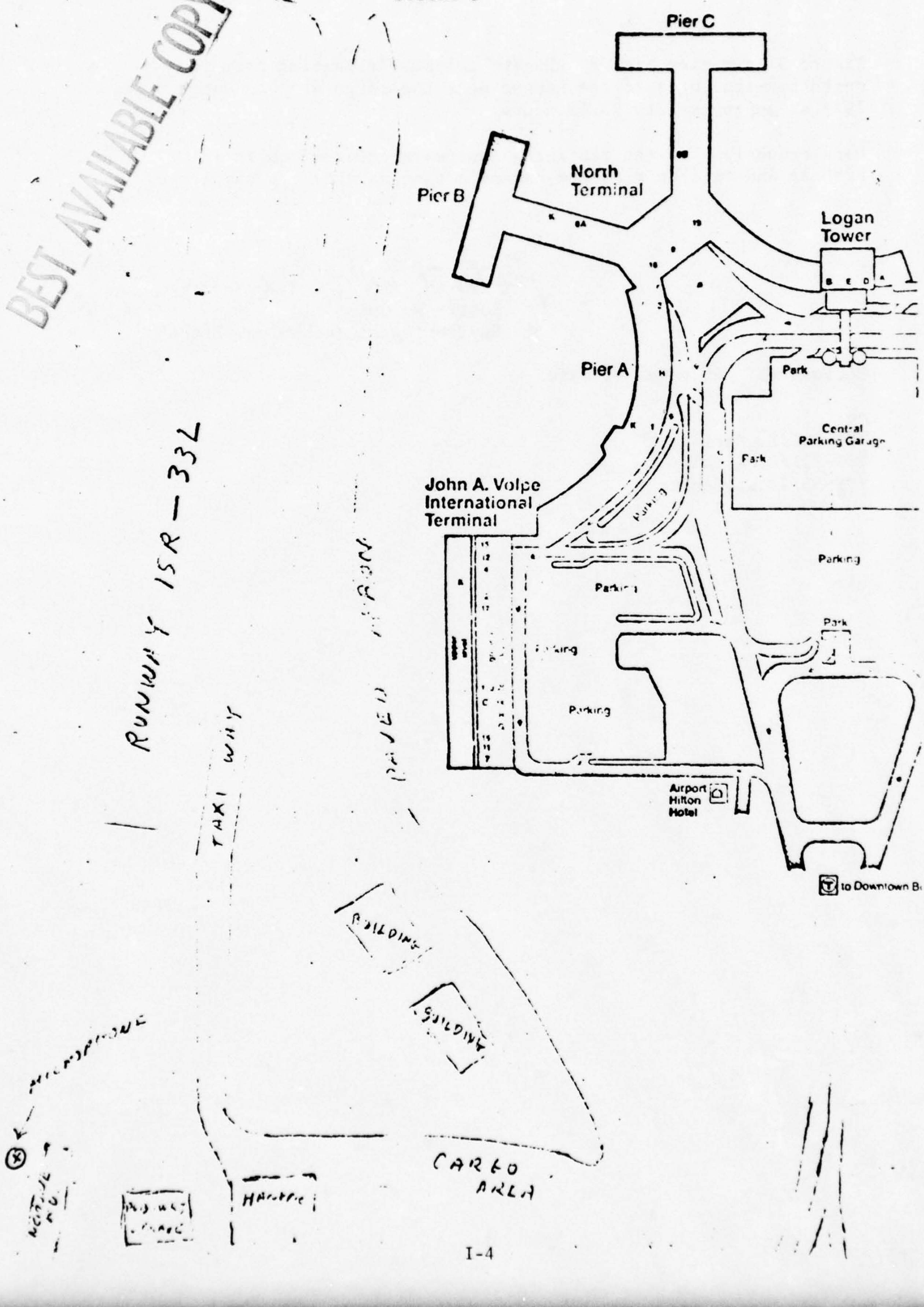

Pier C
North Terminal
Pier B
Logan Tower
Pier A
Park
Central Parking Garage
Park
John A. Volpe International Terminal
Parking
Parking
Parking
Parking
Parking
Park
Airport Hilton Hotel
RUNWAY 15R — 33L
TAXI WAY
BUILDING
BUILDING
MICROPHONE
CARGO AREA

TABLE 1

STATISTICAL INDEXES
COMMUNITY NOISE DATA
NEPTUNE ROAD, E. BOSTON, MASS.

JANUARY 19 1977

RUN START TIME 09:39

T	A	S	E	N	M	R	1	10	50	90	99
1	57.9	10.4	78.1	104.7	97.0	48.0	93.0	75.9	53.4	51.7	51.0
2	57.4	8.9	76.2	99.0	98.0	49.0	91.7	72.2	54.6	52.2	51.1
3	62.6	11.8	80.9	111.1	99.0	49.0	95.4	83.5	59.2	52.2	51.1
4	61.2	11.5	80.7	110.1	98.0	48.0	95.1	81.3	56.5	52.3	51.1
5	60.1	10.9	81.9	109.8	103.0	54.0	96.6	78.1	56.4	52.0	50.8
50	59.8	10.9	80.0	107.9	103.0	54.0	94.6	78.7	55.5	52.1	51.0

RUN START TIME 10:35

1	59.7	11.2	81.1	109.8	101.0	51.0	95.5	79.5	55.2	52.3	51.2
2	58.8	10.7	80.8	108.2	100.0	50.0	95.9	77.2	54.4	52.4	51.3
3	60.9	11.1	81.2	109.6	99.0	49.0	95.8	79.6	57.5	52.4	51.2
4	57.9	9.1	75.8	99.1	97.0	47.0	90.7	72.0	54.6	52.1	51.1
5	59.4	10.1	79.2	105.1	99.0	49.0	95.0	76.1	55.5	52.4	51.2
50	59.3	10.5	80.0	106.9	101.0	51.0	95.1	76.5	55.1	52.3	51.2

RUN START TIME 11:33

1	57.4	8.5	76.4	98.2	98.0	48.0	91.5	68.3	54.7	52.5	51.5
2	62.7	11.8	82.3	112.5	100.0	50.0	96.1	85.0	58.9	53.2	51.7
3	59.0	9.1	76.8	100.1	96.0	46.0	92.2	72.7	56.0	52.6	51.4
4	58.9	9.4	79.5	103.6	102.0	52.0	95.1	71.7	55.5	53.1	52.0
5	58.9	9.2	78.6	102.2	101.0	51.0	93.8	71.0	56.1	52.5	51.3
50	59.4	9.8	79.3	104.4	102.0	52.0	94.3	74.7	55.9	52.7	51.5

RUN START TIME 12:34

1	61.1	12.1	84.5	115.5	105.0	55.0	99.6	80.3	57.7	51.0	50.1
2	57.5	10.4	79.6	106.2	101.0	51.0	95.0	73.5	53.1	50.5	50.1
3	53.4	4.7	60.1	72.1	81.0	31.0	73.9	59.0	52.4	50.6	50.1
4	58.5	10.9	78.0	105.9	97.0	47.0	92.0	78.4	54.1	50.9	50.1
5	62.9	13.3	83.3	117.3	101.0	51.0	96.9	85.8	56.6	52.1	50.5
50	58.7	11.2	81.2	109.9	105.0	55.0	96.0	77.3	54.2	50.9	50.1

TABLE 2

STATISTICAL INDEXES
COMMUNITY NOISE DATA
NEPTUNE ROAD, E. BOSTON, MASS.

JANUARY 26 1977

RUN START TIME 21:10 HOURS

T	A	S	E	N	M	R	1	10	50	90	99
1	60.0	6.1	68.8	84.4	90.0	39.0	83.8	67.8	59.6	54.3	52.5
2	58.5	7.6	80.9	100.4	105.0	55.0	95.4	66.3	56.6	53.3	52.0
3	54.0	2.9	55.7	63.1	71.0	21.0	65.5	58.7	53.6	52.1	51.1
4	55.0	4.5	58.9	70.4	77.0	27.0	70.7	62.3	53.7	51.7	50.6
5	57.0	3.4	58.7	67.4	71.0	21.0	67.7	62.2	57.1	53.5	51.4
50	56.9	5.6	74.3	88.6	105.0	55.0	79.5	63.9	55.9	52.4	51.1

RUN START TIME 22:04 HOURS

T	A	S	E	N	M	R	1	10	50	90	99
1	56.9	3.9	59.2	69.2	71.0	20.0	68.7	63.7	56.1	53.7	52.4
2	60.3	8.3	82.8	104.0	105.0	54.0	95.9	69.3	58.5	53.8	52.2
3	54.4	4.2	63.3	74.1	86.0	36.0	76.1	58.2	53.8	52.2	51.1
4	59.2	2.8	60.2	67.4	69.0	17.0	67.0	63.4	59.5	56.1	54.0
5	55.2	3.0	56.8	64.5	71.0	21.0	66.7	59.8	54.8	52.8	51.5
50	57.2	5.4	75.9	89.7	105.0	55.0	79.2	63.6	56.3	53.0	51.6

RUN START TIME 23:06 HOURS

T	A	S	E	N	M	R	1	10	50	90	99
1	55.9	3.0	57.1	64.8	67.0	16.0	64.5	61.0	55.6	53.1	51.9
2	59.1	3.2	60.4	68.6	72.0	20.0	67.4	63.9	59.4	55.4	53.4
3	57.7	3.0	59.4	67.1	75.0	23.0	70.5	61.7	57.5	55.3	53.6
4	58.4	2.3	59.2	65.1	73.0	21.0	66.5	61.7	58.5	56.3	55.0
5	64.5	3.9	66.7	76.7	84.0	29.0	76.3	69.9	64.7	60.0	57.2
50	59.1	4.3	62.1	73.1	84.0	33.0	72.6	65.4	58.8	54.8	52.5

SPECIFIC EVENTS
NEPTUNE ROAD, E. BOSTON, MASS.
JET AIRCRAFT DEPARTURES, RUNWAY 33L

	JET AIRCRAFT			PROP AIRCRAFT
	3/4 ENG WIDE BODY AVERAGE OF MAX DBA'S	2/3 ENG NAR. BODY AVERAGE OF MAX DBA'S	4 ENG NAR. BODY AVERAGE OF MAX DBA'S	2/4 ENG AVERAGE OF MAX DBA'S
JANUARY 19, 1977 RUN START TIME 09:39	5 EVENTS 88.7	9 EVENTS 96.3	1 EVENT 88.5	1 EVENT 77.3
JANUARY 19, 1977 RUN START TIME 10:35	2 EVENTS 91.8	11 EVENTS 96.5	1 EVENT 91.0	1 EVENT 79.0
JANUARY 19, 1977 RUN ~~TIME~~ START TIME 11:33	0 EVENTS ----	10 EVENTS 96.5	1 EVENT 88.6	2 EVENTS 81.7
JANUARY 19, 1977 RUN START TIME 12:34	0 EVENTS ----	10 EVENTS 97.2	1 EVENT 90.0	2 EVENTS 82.2
JANUARY 26, 1977 RUN START TIME 21:10	1 EVENT 88.8	1 EVENT 103.5	0 EVENTS ----	1 EVENT 80.5
JANUARY 26, 1977 RUN START TIME 22:04	0 EVENTS ----	0 EVENTS ----	1 EVENT 105.0	2 EVENTS 87.5
JANUARY 26, 1977 RUN START TIME 23:~~04~~ 06	0 EVENTS ----	0 EVENTS ----	0 EVENTS ----	0 EVENTS ----

TABLE 4

SPECIFIC EVENTS
NEPTUNE ROAD, E. BOSTON, MASS.
AIRCRAFT RUNUP & TAXI OPERATIONS

	PROP. PLANE TAXIING MAX. DBA	JET PLANE TAXIING MAX. DBA	PROP. PLANE RUNUP MAX. DBA	JET PLANE RUNUP MAX. DBA
JANUARY 19 1977 RUN START TIME 09:39	----	----	----	----
JANUARY 19 1977 RUN START TIME 10:35	----	----	----	----
JANUARY 19 1977 RUN START TIME 11:33	66.5	59.0	----	----
JANUARY 19 1977 RUN START TIME 12:34	----	----	----	----
JANUARY 26 1977 RUN START TIME 21:10	----	70.5	----	----
JANUARY 26 1977 RUN START TIME 22:04	----	67.0	----	67.0 66.0
JANUARY 26 1977 RUN START TIME 23:06	65.3 64.5	68.8 80.5 68.5 82.0	63.3	----

TABLE 5

SPECIFIC EVENTS
NEPTUNE ROAD, E. BOSTON, MASS.
AUTOMOBILE & TRUCK PASSBYS

	TRUCKS ON PERIMETER ROAD			AUTOMOBILES ON NEPTUNE ROAD		
	NUMBER OF EVENTS		AVERAGE OF MAX. DBA'S	NUMBER OF EVENTS		AVERAGE OF MAX. DBA'S
	*	**		*	**	
JANUARY 19 1977 RUN START TIME 09:39	5	4	62.5	1	0	----
JANUARY 19 1977 RUN START TIME 10:35	5	9	59.9	0	1	54.8
JANUARY 19 1977 RUN START TIME 11:33	1	7	61.5	0	0	----
JANUARY 19 1977 RUN START TIME 12:34	2	2	63.7	1	1	57.5
JANUARY 26 1977 RUN START TIME 21:10	2	3	62.1	3	0	----
JANUARY 26 1977 RUN START TIME 22:04	0	8	62.9	4	0	----
JANUARY 26 1977 RUN START TIME 23:05	0	4	64.3	2	0	----

BEST AVAILABLE COPY

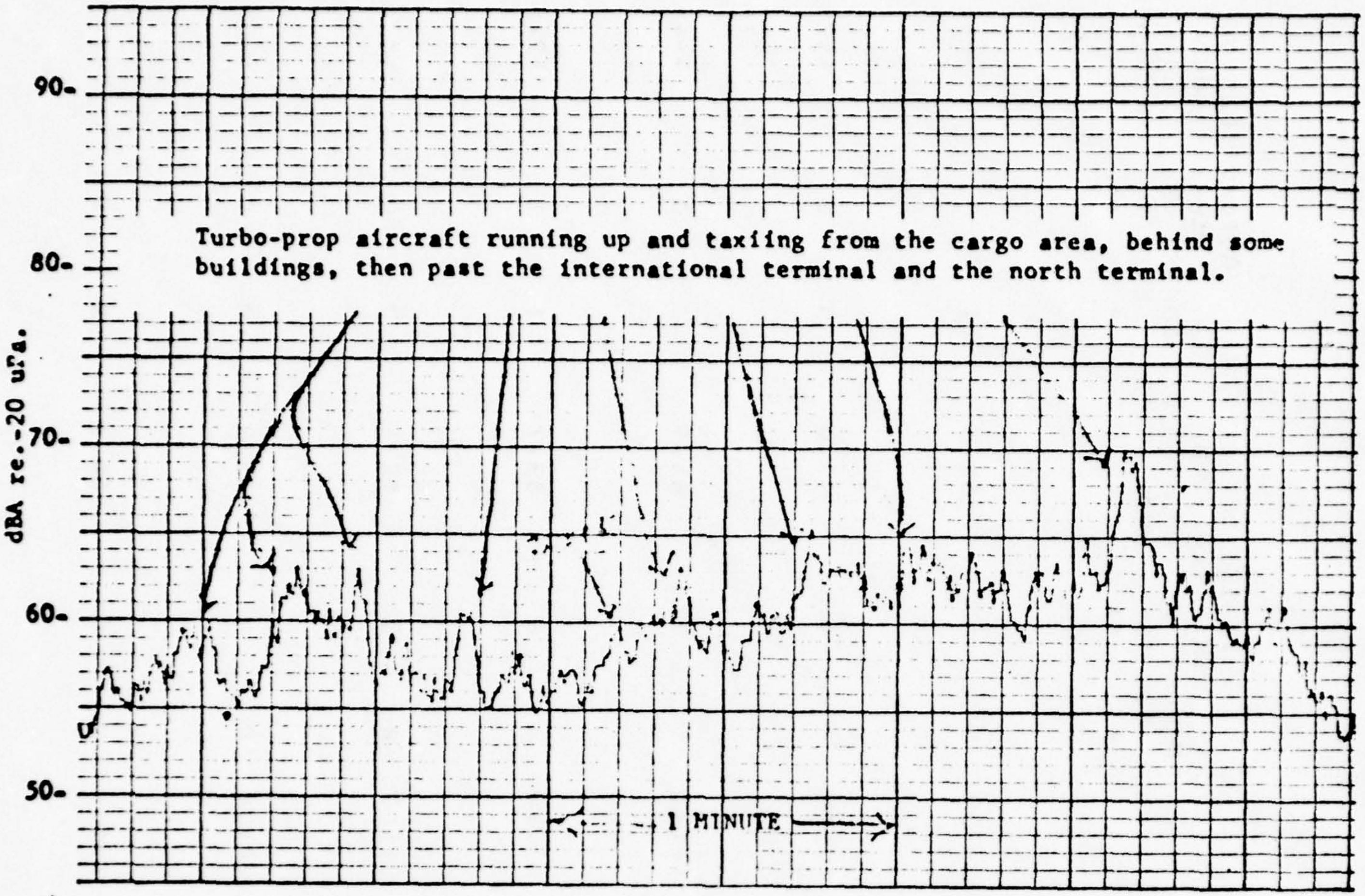


FIGURE 2
TIME HISTORY
TURBO-PROP AIRCRAFT RUNUP & TAXI
JANUARY 26 1977 23:30

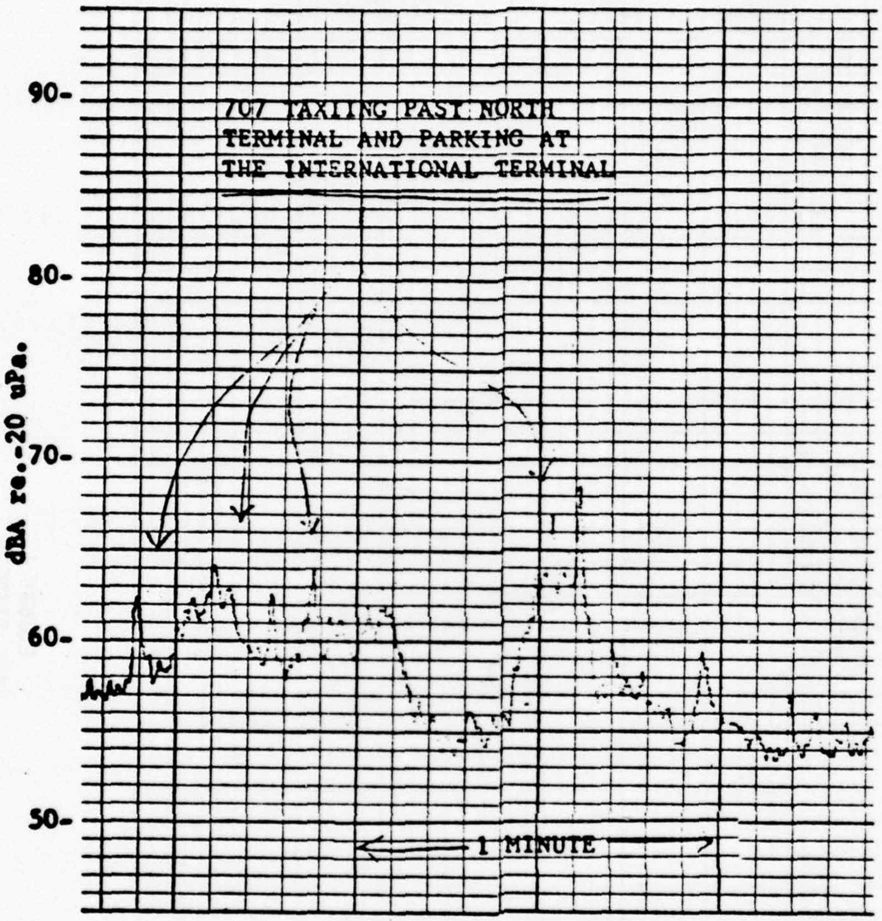


FIGURE 3
TIME HISTORY
707 TAXIING
JANUARY 26 1977 23:15

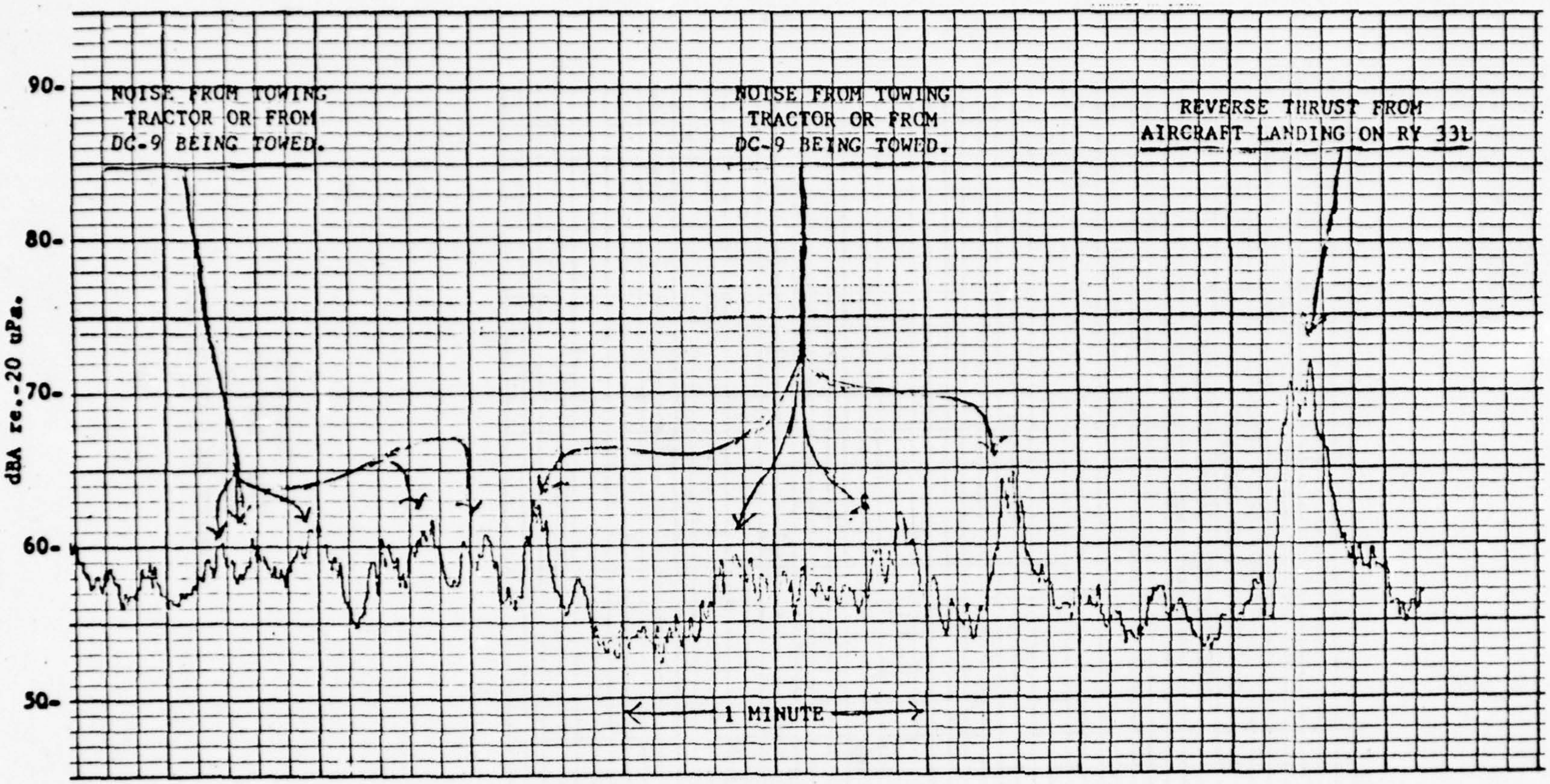


FIGURE 4
TIME HISTORY
DC-9 BEING TOWED
JANUARY 26 1977 23:30

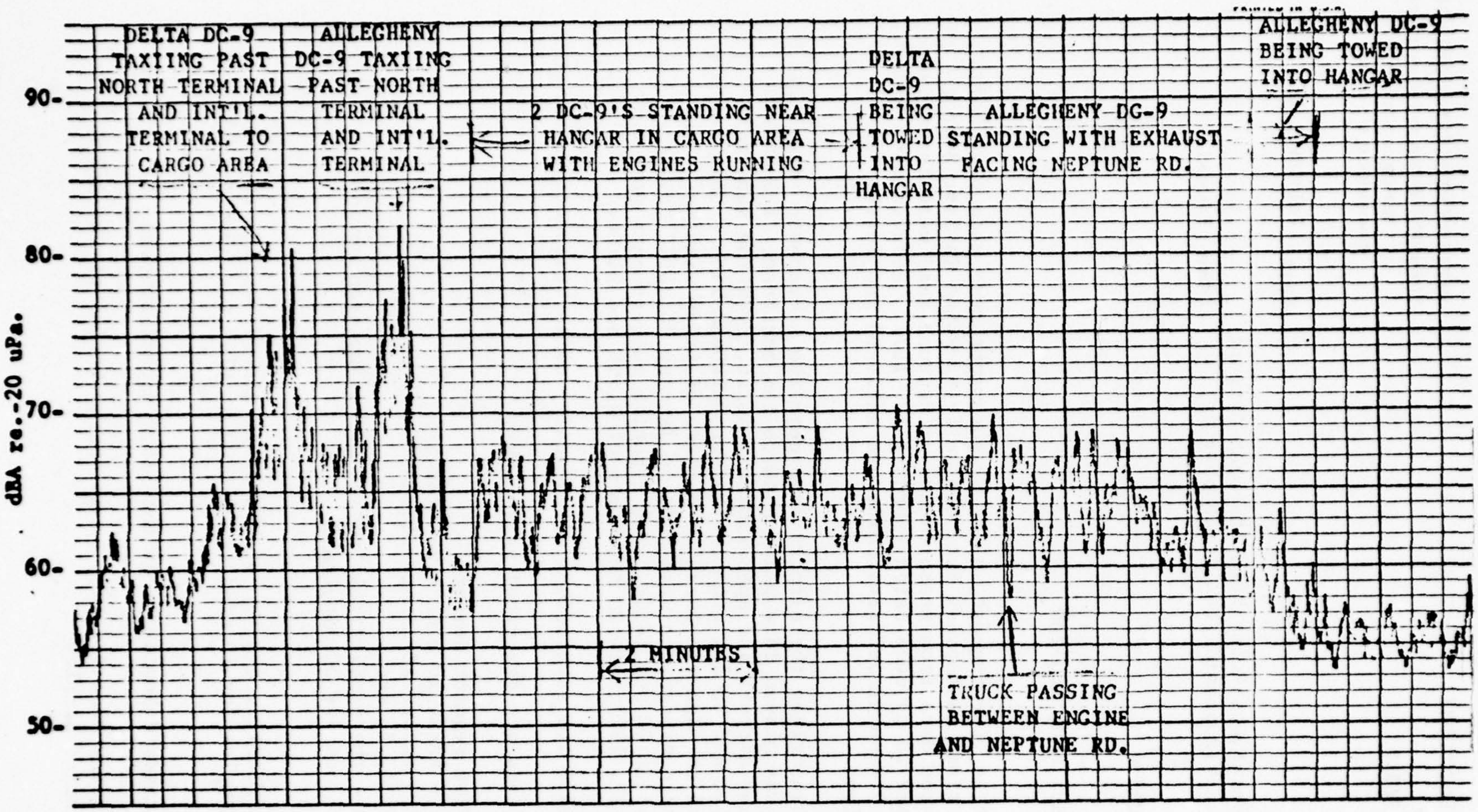


FIGURE 5
TIME HISTORY
TWO DC-9'S TAXIING
JANUARY 26 1977 23:45

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE
CAMBRIDGE, MA 02142

DATE: February 16, 1977

SUBJECT: Aircraft Operations Noise Data At Logan Airport (PPA FP706 Environmental Quality Support)

In reply refer to: TSC-331

FROM: Robert W. Quinn

TO: Edmund W. Sellman, AEQ-200

In response to your request, noise measurements were made near Logan Airport at sites on Neptune Road and Jeffries Point in East Boston Mass. Reduced data from measurements at Neptune Road were forwarded and explained in my memo dated February 10, 1977. Reduced data from measurements made at Jeffries Point are enclosed and further explained below.

Figure 1 illustrates the airport area near the microphone site. The microphone was placed in a playground to the northeast of Sumner Street at the airport and approximately 40 ft. from the near edge of the street and 10 ft. from the harbor bulkhead line. Noise data was recorded on magnetic tape for periods of fifty minutes each. Four daytime measurements were made on January 20, 1977 between the hours of 10:00 and 14:00. Two nightime measurements were made on January 27, 1977 between the hours of 21:00 and 24:00.

Tables 1 and 2 are tabulations of community noise statistical indexes.

Column headings are described as follows:

T - Time segment number
  1 - first 10 minute segment
  2 - second 10 minute segment
  3, 4, 5, etc.
  50 - the statistical indexes are calculated on the entire 50 minutes.

A - Arithmetic average of the 1/8th second samples (4,800 samples for 10 minutes, 24,000 samples for 50 minutes)

S - Standard Deviation of the 1/8th second samples

E - Energy Mean (average on an energy basis) of the 1/8th second samples

N - Noise Pollution Level calculated using the energy mean and standard deviation.

M - Highest 1/8th second sample during the period T.

R - Range (max, minus min.) of the 1/8th second samples during the period T.

1, 10, 50, 90 and 99 - L(x) = 1, 10, 50, 90 or 99

L(x) - the noise level exceeded x percent of the time during period T.

These tables are arranged so that each 50 minutes is represented by one block of statistical data in the table. Each block lists the above indexes for each of the five contiguous ten minute segments followed by the same indexes for the full 50 minute period. Table 1 contains four blocks of data for the four daytime runs. Table 2 contains three blocks of data for the two nighttime runs.

Tables 3, 4, and 5 are tabulated noise measurements of specific events, from airport operations and community activities that were noted during the measurement periods. A graphic level time history recording was prepared for each 50 minute measurement using an averaging time approximating the slow response of a sound level meter. The maximum noise level of each specific event was tabulated. Table 3 is a tabulation of aircraft departures using runways 33L, 22 and 27. The tabulated values are the arithmetic average of the maximum noise levels measured. Table 4 is a tabulation of aircraft runup and taxi operations. The tabulated values are the maximum noise levels for each event. Table 5 is a tabulation of automobile and truck passbys and helicopter flyovers. The tabulated values are the maximum noise levels for each event.

Figure 2 is a time history showing the noise generated by a turbo-prop aircraft running up and taxiing near the Eastern Airlines terminal, and a DC-9 taxiing from the Fire Station to the Eastern Airlines Cargo Building.

Data reductions for the remaining measurement site is in process and will be reported as soon as it is completed.

Robert W. Quinn

Robert W. Quinn
Environmental Technology Branch

Enclosures: 7 pages of data

cc : TSC-331/E. Darling TSC-331/E. Rickley TST-53/J. E. Wesler

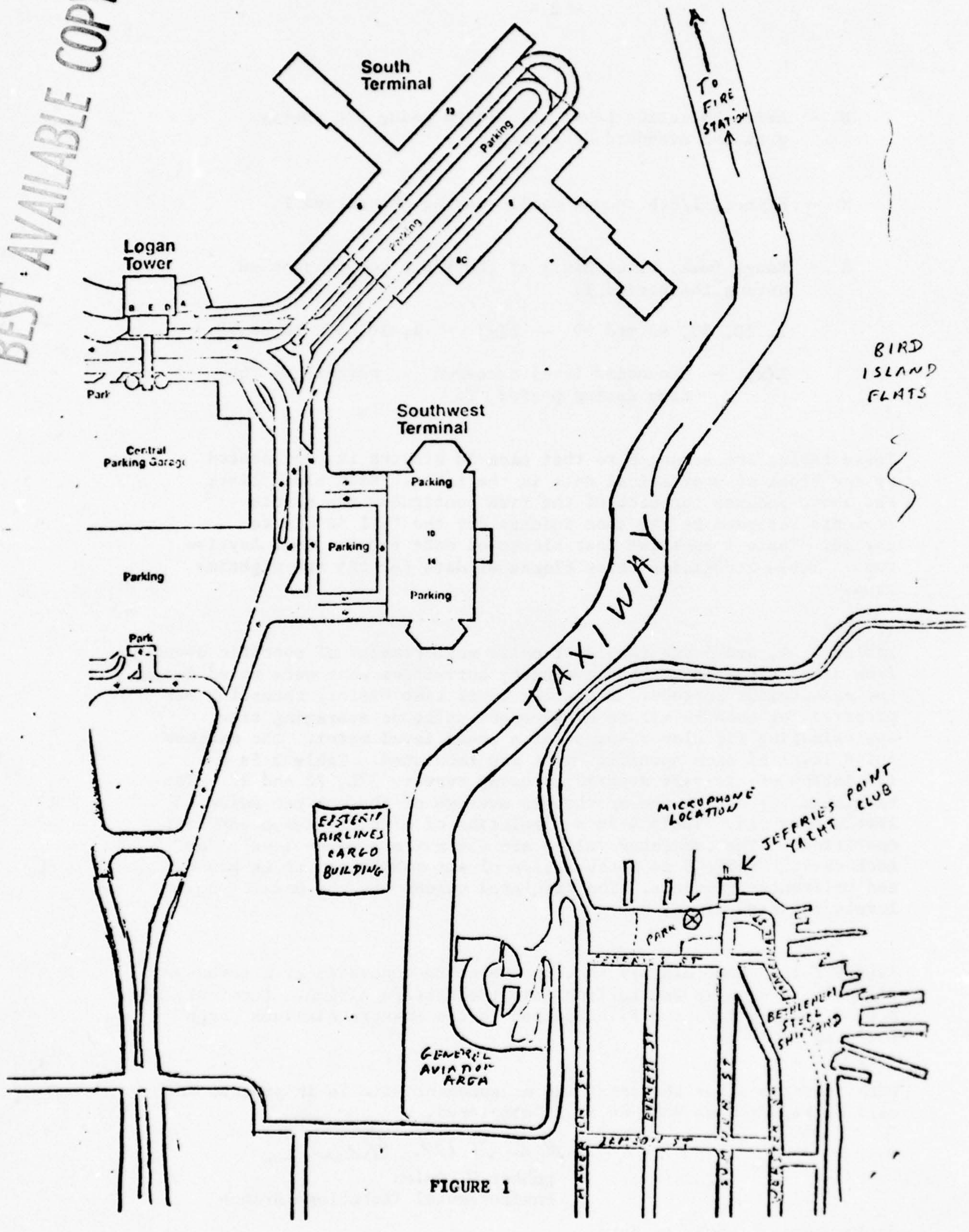

South Terminal
Parking
Parking
Logan Tower
Park
Central Parking Garage
Southwest Terminal
Parking
Parking
Parking
Parking
Park
TO FIRE STATION
TAXIWAY
BIRD ISLAND FLATS
EASTERN AIRLINES CARGO BUILDING
MICROPHONE LOCATION
JEFFRIES POINT YACHT CLUB
PARK
BETHLEHEM STEEL SHIPYARD
GENERAL AVIATION AREA

FIGURE 1

TABLE 1

STATISTICAL INDEXES
COMMUNITY NOISE DATA
JEFFRIES POINT, E. BOSTON, MASS.

JANUARY 20 1977

RUN START TIME 10:00

T	A	S	E	N	M	R	1	10	50	90	99
1	61.7	4.4	64.6	75.9	82.0	29.0	75.0	67.4	62.1	56.7	55.0
2	65.4	6.0	69.5	84.9	85.0	33.0	79.6	73.8	65.9	57.4	54.6
3	58.9	6.8	65.8	83.2	84.0	34.0	78.1	70.2	56.7	53.1	51.8
4	55.7	4.6	61.2	73.0	81.0	31.0	74.0	61.3	55.1	52.5	51.1
5	57.4	5.3	62.8	76.4	82.0	31.0	74.7	66.5	56.0	53.3	52.0
50	59.8	6.5	65.8	82.4	85.0	35.0	77.4	70.0	58.4	53.5	51.7

RUN START TIME 10:54

T	A	S	E	N	M	R	1	10	50	90	99
1	60.1	5.5	64.5	78.6	82.0	31.0	75.7	68.6	59.4	54.6	53.1
2	59.1	4.1	62.4	72.9	81.0	29.0	73.8	65.4	58.6	55.5	53.8
3	60.3	7.3	66.9	85.6	83.0	32.0	77.7	71.9	57.7	53.7	52.4
4	58.2	6.2	65.4	81.3	82.0	31.0	78.1	68.5	56.4	53.7	52.2
5	57.3	5.2	62.1	75.4	80.0	31.0	74.0	65.8	57.1	51.9	50.3
50	59.0	5.9	64.6	79.7	83.0	34.0	76.7	68.7	57.7	53.8	51.3

RUN START TIME 11:55

T	A	S	E	N	M	R	1	10	50	90	99
1	60.0	6.9	66.1	83.8	83.0	33.0	77.0	71.0	58.8	53.0	51.4
2	56.9	5.7	62.2	76.8	81.0	33.0	74.0	66.1	55.2	52.1	50.4
3	58.2	5.0	62.3	75.1	84.0	35.0	72.9	65.9	57.8	53.0	51.1
4	65.2	5.1	68.1	81.2	84.0	32.0	77.6	72.1	65.9	58.8	54.3
5	59.8	6.0	64.9	80.3	82.0	33.0	75.9	69.6	59.2	53.7	51.4
50	60.0	6.4	65.3	81.7	84.0	36.0	76.0	69.8	59.5	53.1	51.1

RUN START TIME 12:54

T	A	S	E	N	M	R	1	10	50	90	99
1	57.4	4.9	63.7	76.2	87.0	36.0	76.7	62.5	56.8	53.8	52.3
2	62.1	7.0	68.8	86.7	85.0	34.0	80.7	73.5	59.7	55.6	54.0
3	57.5	5.9	64.2	79.3	83.0	33.0	76.8	67.8	55.8	53.1	51.4
4	58.7	7.4	67.4	86.3	88.0	40.0	79.6	71.8	56.5	52.5	50.6
5	61.5	7.9	69.3	89.5	85.0	35.0	80.6	73.9	59.6	53.3	51.2
50	59.5	7.0	67.3	85.2	88.0	40.0	79.5	71.5	57.5	53.3	51.3

TABLE 2

STATISTICAL INDEXES
COMMUNITY NOISE DATA
JEFFRIES POINT, E. BOSTON, MASS.

JANUARY 27 1977

RUN START TIME 20:58

T	A	S	E	N	M	R	1	10	50	90	99
1	53.4	4.8	57.2	69.5	75.0	31.0	68.3	60.6	53.0	48.6	46.9
2	57.5	5.8	61.5	76.3	77.0	30.0	71.5	65.9	57.6	50.9	48.8
3	50.5	3.7	53.0	62.5	71.0	27.0	63.2	56.0	49.9	47.2	45.6
4	50.9	4.7	55.2	67.2	77.0	33.0	66.7	57.7	49.7	46.7	45.3
5	51.3	4.8	55.6	67.9	73.0	28.0	67.5	59.1	50.0	47.6	46.1
50	52.7	5.5	57.5	71.6	77.0	33.0	69.1	61.4	51.7	47.6	46.0

RUN START TIME 22:57

T	A	S	E	N	M	R	1	10	50	90	99
1	52.4	2.1	53.2	58.6	67.0	19.0	61.7	55.2	52.5	50.8	49.5
2	51.0	1.4	51.2	54.8	57.0	11.0	55.3	53.4	51.4	49.6	48.3
3	50.8	1.6	51.8	55.9	78.0	31.0	56.4	53.0	51.2	49.6	48.3
4	51.5	1.9	52.2	57.1	69.0	22.0	58.3	54.2	51.8	49.8	48.4
5	53.9	2.1	54.5	59.9	66.0	17.0	60.7	57.1	54.2	51.8	50.5
50	51.9	2.2	52.7	58.3	78.0	32.0	59.6	55.2	52.1	50.1	48.6

TABLE 3

SPECIFIC EVENTS
JEFFRIES POINT, E. BOSTON, MASS.
AIRCRAFT DEPARTURES

	JET AIRCRAFT			PROP AIRCRAFT	
	RWY 22	RWY 27	RWY 33	RWY 22	RWY 27
JANUARY 20 1977 RUN START TIME: 1000		8 EVENTS 75.4 1 EV.(M)	4 EVENTS 77.8		1 EVENT 72.2 1 EV.(M)
JANUARY 20 1977 RUN START TIME:1054		10 EVENTS 78.0			1 EVENT 73.0
JANUARY 20 1977 RUN START TIME:1155		13 EVENTS 77.5	1 EVENT 70.0		2 EVENTS 70.9
JANUARY 20 1977 RUN START TIME: 1254		13 EVENTS 80.6			1 EVENT 70.0
JANUARY 27 1977 RUN START TIME: 2058	7 EVENTS 69.2			2 EVENTS 60.5	
JANUARY 27 1977 RUN START TIME: 2257	2 EVENTS 61.5			2 EVENTS 65.0	

(M) LOW LEVELS OBSCURED BY OTHER NOISY EVENTS.

TABLE 4

JEFFERIES POINT SPECIFIC EVENTS
NEPTUNE ROAD, E. BOSTON, MASS.
AIRCRAFT RUNUP & TAXI OPERATIONS

	PROP. PLANE TAXIING MAX. DBA	JET PLANE TAXIING MAX. DBA	PROP. PLANE RUNUP MAX. DBA	JET PLANE RUNUP MAX DBA
JANUARY 20, 1977 RUN START TIME 10:00	70.0 1 EVENT <55	68.3 58.2 59.2 1 EVENT (M) 3 EVENTS <55	----	73.3
JANUARY 20, 1977 RUN START TIME 10:54	62.0 64.0	75.5 64.5 64.0 66.5 1 EVENT (M)	----	59.3
JANUARY 20, 1977 RUN START TIME 11:55	60.0 1 EVENT (M) 2 EVENTS <55	61.0 71.0 66.3 3 EVENTS (M)	----	----
JANUARY 20, 1977 RUN START TIME 12:54	----	3 LOW LEVEL	----	----
JANUARY 27, 1977 RUN START TIME 20:58	58.3 59.3	63.0 56.0 56.8 64.0	----	----
JANUARY 27, 1977 RUN START TIME 22:57	1 EVENT <55	57.3 64.5 61.0 2 EVENTS <55	----	----

(M) LOW LEVELS OBSCURED BY OTHER NOISY EVENTS

TABLE 5

SPECIFIC EVENTS
JEFFRIES POINT, E. BOSTON, MASS.

	HELICOPTER FLYOVERS	CAR OR SMALL TRUCK ON SUMNER ST.	LARGE TRUCK ON SUMNER ST.
JANUARY 20 1977 RUN START TIME 10:00	----	----	----
JANUARY 20 1977 RUN START TIME 10:54	74.0 64.0 1 EVENT <55	----	----
JANUARY 20 1977 RUN START TIME 11:55	73.5 79.0 1 EVENT (M)	----	----
JANUARY 20 1977 RUN START TIME 12:54	1 EVENT (M)	62.0	60.0
JANUARY 27 1977 RUN START TIME 20:58	----	2 EVENTS <55	----
JANUARY 27 1977 RUN START TIME 22:57	----	2 EVENTS <55	----

(M) - LOW LEVELS OBSCURED BY OTHER NOISY EVENTS.

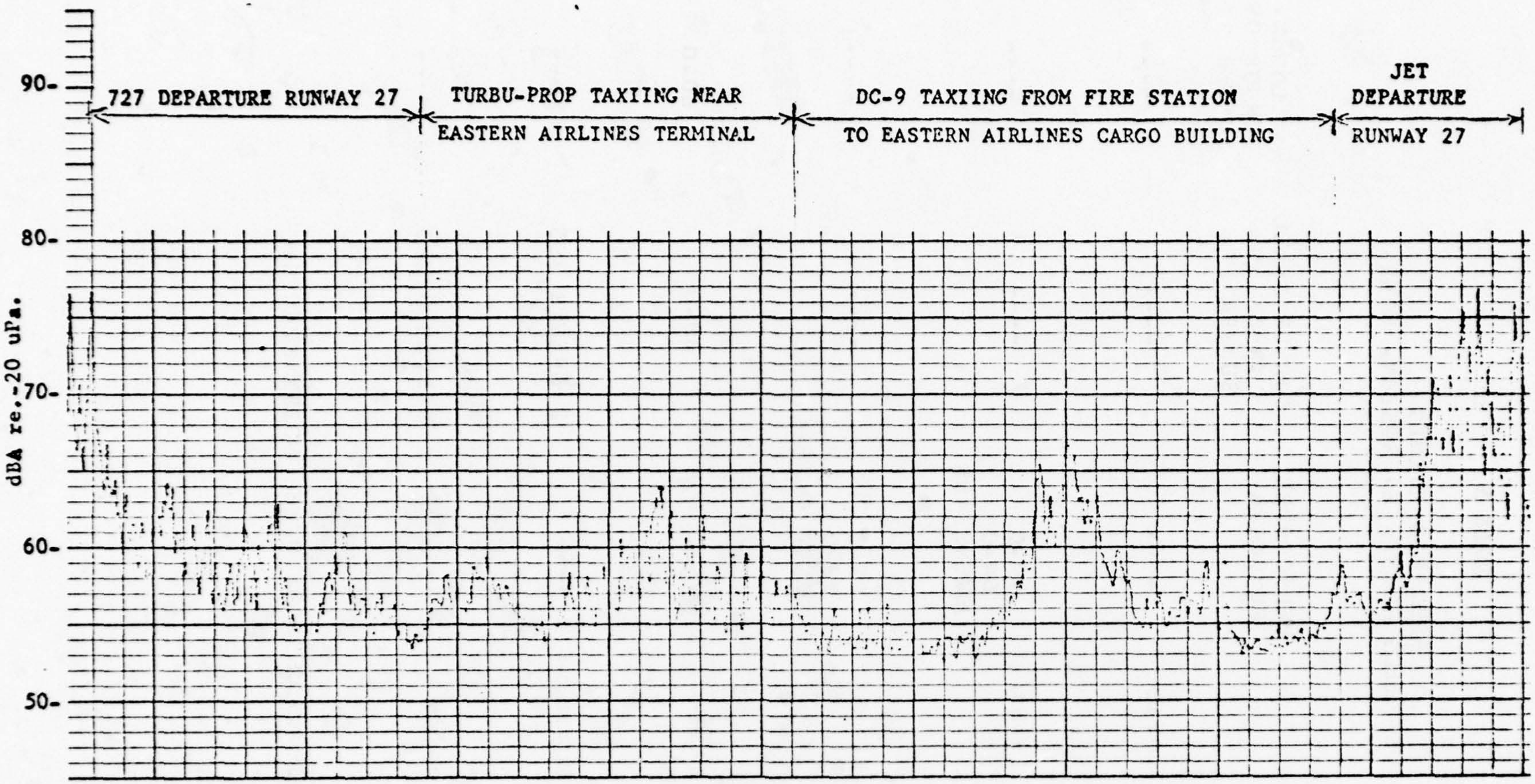


FIGURE 2
TIME HISTORY
TURBO-PROP. & DC-9 TAXIING
JANUARY 20 1977, 11:12

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE
CAMBRIDGE, MA 02142

DATE: March 7 1977

SUBJECT: Aircraft Operations Noise Data At Logan Airport (PPA FP706 Environmental Quality Support)

In reply refer to: TSC-331

FROM: Robert W. Quinn

TO: Edmund W. Sellman, AEQ-200

In response to your request, noise measurements were made near Logan Airport at sites on Neptune Road and Jeffries Point in East Boston Mass. Reduced data from measurements at Neptune Road were forwarded and explained in my memo dated February 10, 1977. Reduced data from measurements made at Jeffries Point were forwarded and explained in my memo dated February 16, 1977. Reduced data from measurements made near the corner of Sumner and Lamson Sts. are enclosed and further explained below.

Figure 1 illustrates the airport area and East Boston streets near the microphone site. The microphone was placed in a vacant lot to the southwest of Sumner St. approximately 100 ft from the near edge of Sumner St. and 20 ft from Lamson St. Noise data was recorded on magnetic tape for periods of fifty minutes each.

Four daytime measurements were made on January 21, 1977 between the hours of 10:00 and 13:00. Nightime measurements were attempted on January 28, 1977 at 21:00, but they were rained out.

Tables 1 and 2 are tabulations of community noise statistical indexes.

Column headings are described as follows:

T - Time segment number
- 1 - first 10 minute segment
- 2 - second 10 minute segment
- 3,4,5, etc.
- 50 - the statistical indexes are calculated on the entire 50 minutes

A - Arithmetic average of the 1/8th second samples (4,800 samples for 10 minutes, 24,000 samples for 50 minutes)

S - Standard Deviation of the 1/8th second samples

E - Energy Mean (average on an energy basis) of the 1/8th second sample

N - Noise Pollution Level calculated using the energy mean and standard deviation.

M - Highest 1/8th second sample during the period T.

R - Range (max, minus min.) of the 1/8th second samples during the period T.

1, 10, 50, 90 and 99 - L(x) = 1, 10, 50, 90 or 99

L(x) - the noise level exceeded x percent of the time during period T.

These tables are arranged so that each 50 minutes is represented by one block of statistical data in the table. Each block lists the above indexes for each of the five contiguous ten minute segments followed by the same indexes for the full 50 minute period. Table 1 contains four blocks of data for the four daytime runs.

Tables 2 and 3 are tabulated noise measurements of specific events, from airport operations and community activities that were noted during the measurement periods. A graphic level time history recording was prepared for each 50 minute measurement using an averaging time approximating the slow response of a sound level meter. The maximum noise level of each specific event was tabulated. Table 2 is a tabulation of aircraft departures using runways 33L. The tabulated values are the arithmetic average of the maximum noise levels measured. Table 4 is a tabulation of aircraft taxi operations. The tabulated values are the maximum noise levels for each event. Table 4 is a tabulation showing weather conditions during measurement periods from January 19, 19[illegible] to February 24, 1977.

Data reduction for the January 23/24 measurements at Jeffries Point is in process and will be reported as soon as it is completed.

Robert W. Quinn
Environmental Technology Branch

cc:
TSC-331/E. Darling
TSC-331/E. Rickley
TST-53 /J.E. Wesler
TSC-50 /J.P. Anderson

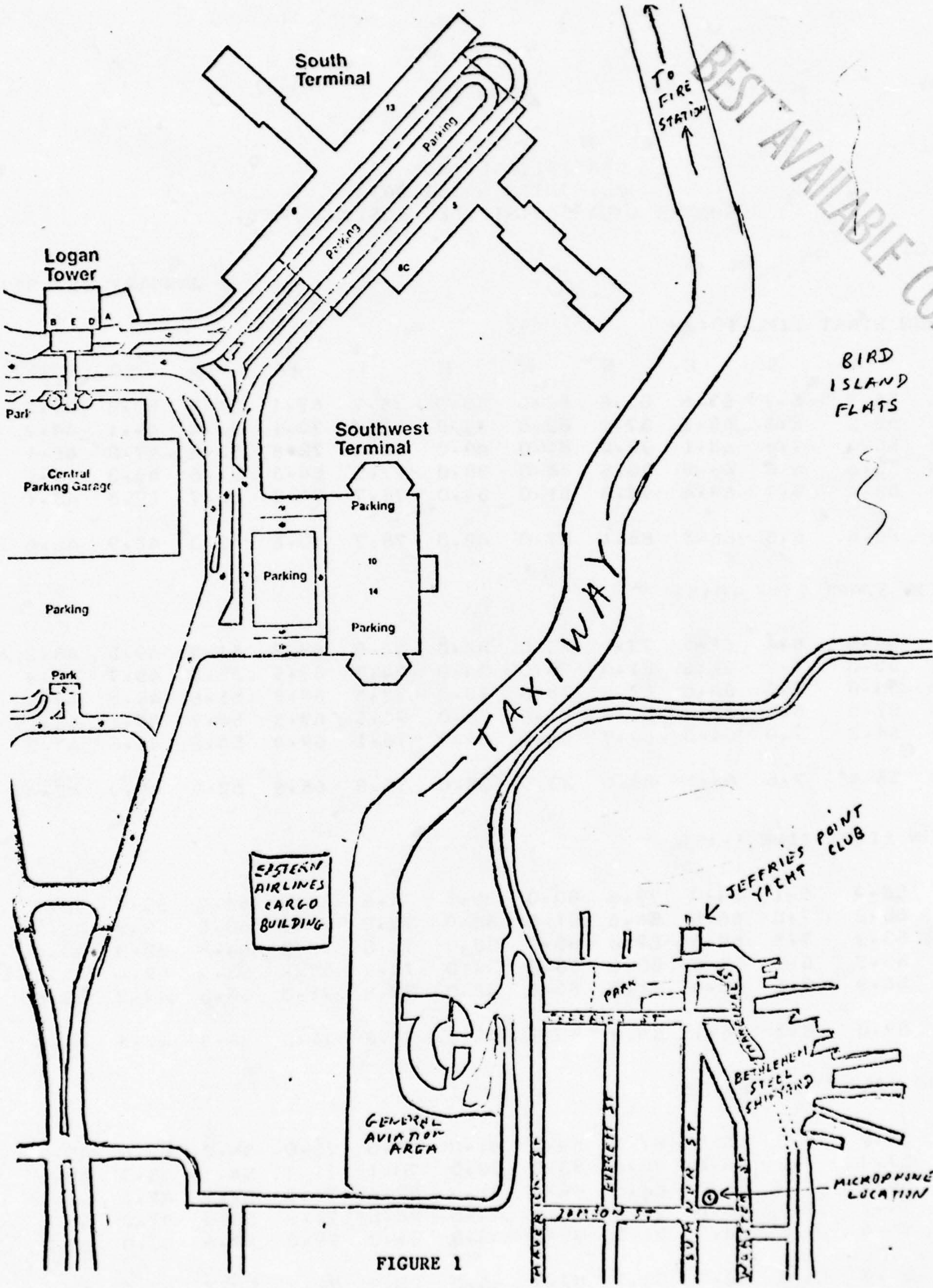

South Terminal
Parking
Parking
Logan Tower
Park
Central Parking Garage
Southwest Terminal
Parking
Parking
Parking
Parking
Park
TO FIRE STATION
TAXIWAY
BIRD ISLAND FLATS
EASTERN AIRLINES CARGO BUILDING
JEFFRIES POINT YACHT CLUB
BETHLEHEM STEEL SHIPYARD
GENERAL AVIATION AREA
MICROPHONE LOCATION
MAVERICK ST
EVERETT ST
SUMNER ST
JOHNSON ST
PARK

FIGURE 1

Table 1

STATISTICAL INDEXES
COMMUNITY NOISE DATA
SUMNER & LAMSON STS. E. BOSTON, MASS.

JANUARY 21 1977

RUN START TIME 10:09

T	A	S	E	N	M	R	1	10	50	90	99
1	56.9	6.7	63.6	80.8	83.0	35.0	75.7	67.1	54.5	50.8	49.2
2	56.2	8.3	65.9	87.1	82.0	37.0	78.3	70.1	53.4	49.1	47.2
3	56.4	9.8	68.1	93.2	87.0	42.0	80.4	72.8	53.4	47.2	46.1
4	53.6	6.6	63.6	80.5	84.0	38.0	77.5	64.3	51.6	49.3	48.1
5	62.4	9.7	69.4	94.2	81.0	34.0	78.7	74.3	65.7	49.3	48.1
50	56.4	8.5	66.3	88.1	87.0	42.0	78.7	70.6	53.3	48.9	46.6

RUN START TIME 10:59

T	A	S	E	N	M	R	1	10	50	90	99
1	54.0	6.4	61.5	77.9	80.0	34.0	74.0	65.5	51.7	49.5	48.2
2	55.3	7.2	62.6	81.0	79.0	34.0	74.3	67.6	52.8	48.7	47.2
3	54.8	7.8	62.8	82.8	78.0	33.0	73.6	68.8	51.6	48.5	47.2
4	57.5	8.2	65.3	86.3	83.0	36.0	76.5	69.8	54.7	49.5	48.1
5	56.3	7.9	64.5	84.7	81.0	35.0	76.1	69.4	54.2	48.8	47.3
50	55.6	7.6	63.5	83.0	83.0	38.0	75.2	68.6	52.7	49.0	47.4

RUN START TIME 11:59

T	A	S	E	N	M	R	1	10	50	90	99
1	58.9	6.1	64.0	79.6	80.0	30.0	74.5	68.9	56.7	53.4	52.1
2	60.2	7.8	66.6	86.6	81.0	35.0	77.2	71.7	60.6	50.9	48.2
3	63.3	7.5	68.6	87.8	85.0	38.0	78.5	73.2	64.8	52.8	49.4
4	55.9	6.9	62.8	80.5	80.0	34.0	74.9	67.3	53.9	49.4	47.4
5	56.9	9.6	66.4	91.0	85.0	42.0	77.8	71.3	53.8	47.2	45.6
50	59.0	8.1	66.1	86.8	85.0	42.0	77.2	71.0	58.3	49.6	46.5

RUN START TIME 12:58

T	A	S	E	N	M	R	1	10	50	90	99
1	56.0	8.5	65.5	87.3	84.0	41.0	77.5	70.0	54.0	47.8	45.1
2	57.4	9.2	66.6	90.2	83.0	38.0	78.1	71.7	54.7	48.3	46.5
3	54.7	8.9	65.7	88.5	84.0	41.0	77.6	71.3	51.7	47.1	45.3
4	55.7	9.3	66.6	90.4	87.0	44.0	78.5	71.3	52.4	47.2	45.1
5	55.4	9.0	68.3	91.3	87.0	43.0	81.0	72.0	52.6	48.0	46.2
50	55.8	9.0	66.7	89.7	87.0	44.0	78.9	71.3	52.7	47.6	45.4

Table 2

SPECIFIC EVENTS
SUMNER & LAMSON STS. E. BOSTON, MASS.
AIRCRAFT DEPARTURES

	JET AIRCRAFT RUNWAY 33	PROP. AIRCRAFT RUNWAY 33
JANUARY 21 1977 RUN START TIME 10:09	15 EVENTS 78.0	----
JANUARY 21 1977 RUN START TIME 10:59	7 EVENTS 78.6 1 EVENT (M)	5 EVENTS 67.6 1 EVENT <55 1 EVENT (M)
JANUARY 21 1977 RUN START TIME 11:59	16 EVENTS 77.8	2 EVENTS 71.2
JANUARY 21 1977 RUN START TIME 12:58	11 EVENTS 80.4	4 EVENTS 68.5 1 EVENT (M)

(M) LOW LEVELS OBSCURED BY OTHER NOISY EVENTS.

Table 3

SPECIFIC EVENTS
SUMNER & LAMSON STS. E. BOSTON, MASS.
AIRCRAFT TAXI OPERATIONS

	JET PLANE TAXIING MAX. DBA	PROP. PLANE TAXIING MAX. DBA
JANUARY 21 1977 RRUN START TIME 10:59	3 EVENTS (M) 5 EVENTS <55	----
JANUARY 21 1977 RUN START TIME 10:59	2 EVENTS (M) 3 EVENTS <55	----
JANUARY 21 1977 RUN START TIME 11:59	6 EVENTS (M) 2 EVENTS <55	1 EVENT <55
JANUARY 21 1977 RUN START TIME 12:58	3 EVENTS (M) 4 EVENTS <55	----

(M) LOW LEVELS OBSCURED BY OTHER NOISY EVENTS.

Table 4

WEATHER DATA

DATE	TIME	LOCATION	TEMP. °F	WIND VELOCITY MPH	WIND DIRECTION
1-19-77	10:00	Neptune Rd.	<20	C-7	NW
"	11:00	"	<20	0-6	W
"	12:00	"	20	0	-
"	13:00	"	22	0	-
1-20-77	10:30	Jeffries Point	26	4-6	N
"	11:00	"	28	4-8	N
"	12:00	"	31	6-10	NNW
"	12:35	"	34	6-10	W
1-21-77	10:30	Sumner & Lamson Sts.	33	0	-
"	11:00	"	35	0	-
"	12:00	"	35	0	-
"	13:00	"	37	0	=
1-26-77	20;30	Neptune Rd.	26	3-6	NW
"	21:30	"	26	3-6	NW
"	22:30	"	26	3-6	NW
1-27-77	21:00	Jeffries Point	25	6-10	NW
"	22:00	"	24	8-10	WNW
"	23:30	"	23	2-6	W
2-23-77	21:30	Jeffries Point	39	6-10	S
"	22:00	"	34	6-10	S
"	22:45	"	34	5-10	S
"	23:30	"	33	5-10	S

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
TRANSPORTATION SYSTEMS CENTER
KENDALL SQUARE
CAMBRIDGE, MA 02142

DATE: March 9, 1977

SUBJECT: Aircraft Operations Noise Data At Logan Airport (PPA FP706 Environmental Quality Support)

In reply refer to: TSC-331

FROM: Robert W. Quinn

TO: Edmund W. Sellman, AEQ-200

In response to your request, noise measurements were made near Logan Airport at sites on Neptune Road and Jeffries Point in East Boston Mass. Reduced data from measurements at Neptune Road were forwarded and explained in my memo dated February 10, 1977. Reduced data from measurements made at Jeffries Point were forwarded and explained in my memo dated February 16, 1977. Reduced data from measurements made near the corner of Sumner and Lamson Streets were forwarded and explained in my memo dated March 7, 1977. Reduced data from measurements made at Jeffries Point on February 23 and 24, 1977 are enclosed and further explained below.

Figure 1 illustrates the airport area near the microphone site. The microphone was placed in a playground to the northeast of Sumner Street at the airport end approximately 40 ft. from the near edge of the street and 10 ft. from the harbor bulkhead line. Noise data was recorded for periods of fifty minutes each. Two morning measurements were made on February 23, 1977 between the hours of 07:00 and 09:00. Three late night measurements were made on February 23, 1977 between the hours of 21:00 and 24:00. One early morning measurement was made on February 24, 1977 between the hours of 00:00 and 01:00.

Tables 1 and 2 are tabulations of community noise statistical indexes.

Column headings are described as follows:

T - Time segment number
 1 - first 10 minute segment
 2 - second 10 minute segment
 3, 4, 5, etc.
 50 - the statistical indexes are calculated on the entire 50 minutes

A - Arithmetic average of the 1/8th second samples (4, 800 samples for 10 minutes, 24,000 samples for 50 minutes)

S - Standard Deviation of the 1/8th second samples

E - Energy Mean (average on an energy basis) of the 1/8th second sample

N - Noise Pollution Level calculated using the energy mean and standard deviation.

M - Highest 1/8th second sample during the period T.

R - Range (max, minus min.) of the 1/8th second samples during the period T.

1, 10, 50, 90 and 99 - L(x) = 1, 10, 50, 90 or 99

L(x) - the noise level exceeded x percent of the time during period T.

These tables are arranged so that each 50 minutes is represented by one block of statistical data in the table. Each block lists the above indexes for each of the five contiguous ten minute segments followed by the same indexes for the full 50 minute period. Table 1 contains four blocks of data for the four daytime runs.

Tables 2 and 3 are tabulated noise measurements of specific events, from airport operations and community activities that were noted during the measurement periods. A graphic level time history recording was prepared for each 50 minute measurement using an averaging time approximating the slow response of a sound level meter. The maximum noise level of each specific event was tabulated. Table 2 is a tabulation of aircraft departures using runways 4, 9, 15 and 33. The tabulated values are the arithmetic average of the maximum noise levels measured. Table 4 is a tabulation of aircraft taxi operations. The tabulated values are the maximum noise levels for each event.

Arrangements were made by the F.A.A. Office of Environmental Quality for five controlled experiments to be performed during the approximately six hours of measurement time. The first test was to measure during normal airport operations for the first ten minutes (07:00 to 07:10). Then all runup and taxi operations in the area of the Southwest Terminal, and the near side of the South Terminal were discontinued for the next ten minutes (07:10 to 07:20). Normal airport operations resumed at 07:20 and monitoring continued for three additional ten minute periods until 07:50. The statistical data presented in Table 1 shows that the L(10), L(50), L(90) and L(99) were lower during the second ten minute period (period of discontinued operations) than they were for the first ten minute period (normal operations). However, the same indexes were even lower during the third ten minute period (normal operations plus those aircraft that were on hold for the "quiet" experiment). Actually during the period of discontinued operations (07:10 to 07;20) there was a 727 in the Southwest Terminal area with his engines running who also did some taxiing, and a helicopter was flying in the area between the Southwest and South Terminals. One departure was observed during each or the three ten minute periods as follows:

First period departure from runway 9.

Second period departure from runway 33.

Third period departure from runway 33.

For the second test runup and taxi operations in the Southwest/South terminal area was discontinued, as they were in the second period of the first test. During the "quiet" period an Air Canada L1011 in the Southwest terminal started its engines, taxied from the terminal to the fire station and then its engines were shut down. The engines were then restarted and the L1011 taxied out to its departure runway. The maximum startup noise level measured at the terminal was 70.3 dBA, the maximum taxiing noise level measured was 71.8 dBA. The startup at the fire station could not be heard by personnel at the measurement site, and could not be discerned on the recorded data. Taxi noise from the L1011 as it moved toward its departure runway was measured at a maximum level of 66.3 dBA. Although all other operations in the Southwest/South terminal area was discontinued during this test, airport operations outside that area contributed to measured levels that in some cases were greater than the measured L1011 levels.

The last three tests were made in the late evening. They were towing operations where aircraft were towed from the Southwest terminal to the fire station. Here they were started up then shut down and towed back to the terminal. All taxi and runup operations in the Southwest/South Terminal area were discontinued during these three tests. Noise from the tow tractor and the starting of engines at the fire station could not be heard by personnel at the Jeffries Point measurement site and could not be discerned on the recorded data. It should be noted that during these tests prevailing winds of five to ten miles per hour from the east south east appear to have caused an increase in the low level ambient noise which interfered with the tests.

Please make the following corrections to Table 4 of the data transmitted by my memo of March 7, 1977:

1-20-77	10:30	Jeffries	Point	26	4-6	NW
"	11:00	"	"	28	4-8	NW
"	12:00	"	"	31	6-10	WNW
"	12:35	"	"	34	6-10	WSW
2-23-77	21:30	Jeffries	Point	39	6-10	ESE
"	22:00	"	"	34	6-10	ESE
"	22:45	"	"	34	5-10	ESE
"	23:30	"	"	33	5-10	ESE
"	06:58	"	"	33	0	---

Change the date in the last paragraph of the memo to February 23 and 24, 1977.

This completes the reduction of all the measured data taken for this program If more data or reduction is required don't hesitate to call.

Robert W. Quinn

Robert W. Quinn
Environmental Technology Branch

enclosure

cc:
TSC-33/W. Z. Leavitt TSC-331/E.M.Darling TSC-331/E. Rickley
TSC-50/J. P. Anderson TST53/J. E. Wesler

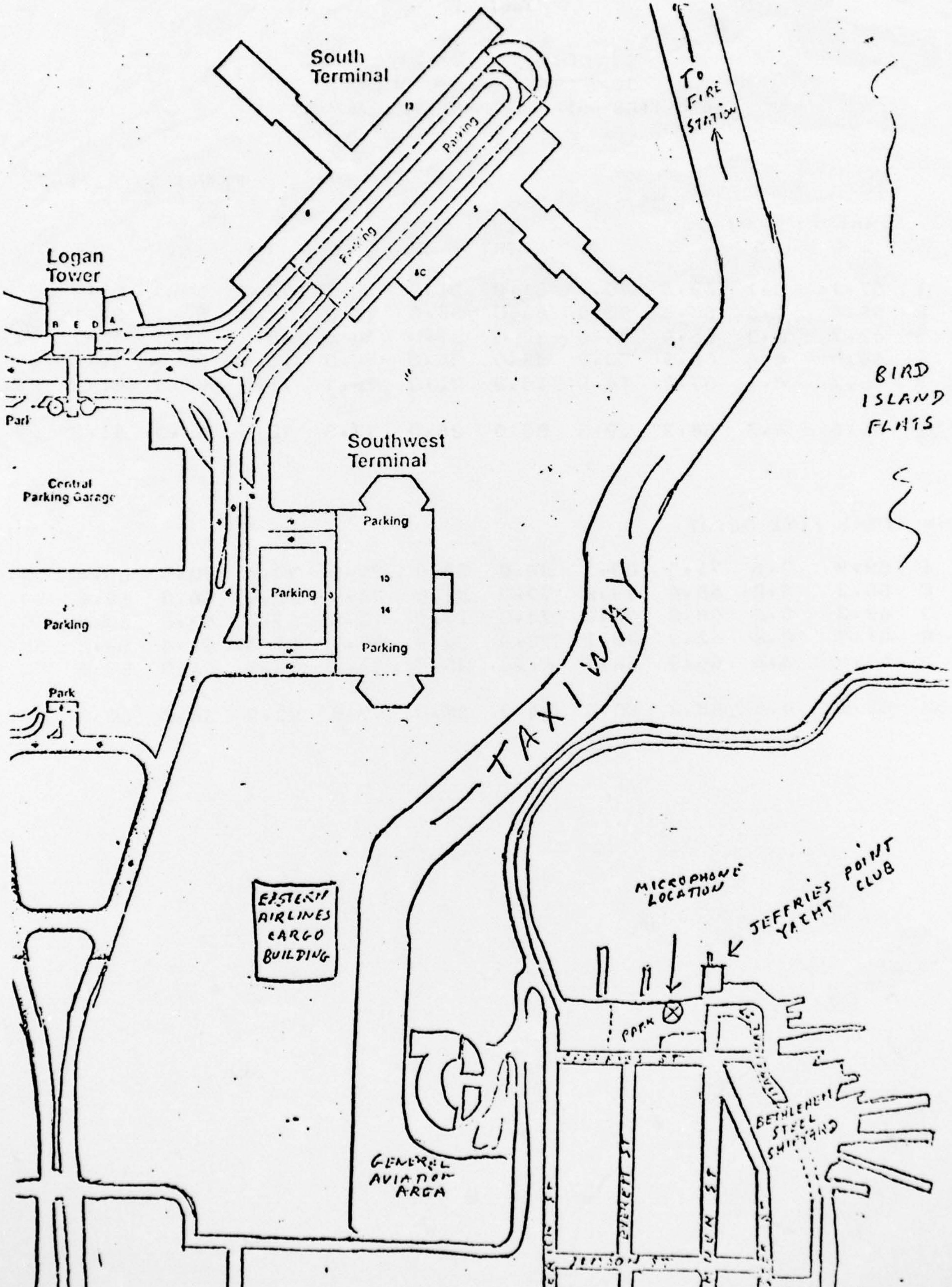

South Terminal
Parking
Parking
Logan Tower
Park
Central Parking Garage
Southwest Terminal
Parking
Parking
Parking
Parking
Park
TO FIRE STATION
BIRD ISLAND FLATS
TAXIWAY
EASTERN AIRLINES CARGO BUILDING
MICROPHONE LOCATION
JEFFRIES POINT YACHT CLUB
BETHLEHEM STEEL SHIPYARD
GENERAL AVIATION AREA

FIGURE 1

Table 1

STATISTICAL INDEXES
COMMUNITY NOISE DATA
JEFFRIES POINT, E. BOSTON, MASS.

FEBRUARY 23 1977

RUN START TIME 07:00

T	A	S	E	N	M	R	1	10	50	90	99
1	67.1	4.1	69.4	79.9	81.0	21.0	78.2	73.8	66.3	63.2	61.7
2	65.4	4.6	68.5	80.3	83.0	25.0	78.2	73.2	64.3	61.1	59.5
3	63.7	3.3	65.4	73.8	79.0	21.0	74.6	68.7	63.5	60.7	59.2
4	66.0	4.6	68.9	80.7	83.0	24.0	78.0	73.6	65.3	61.5	60.1
5	65.7	4.1	67.7	78.2	78.0	21.0	76.1	71.8	65.6	61.3	60.0
50	65.6	4.3	68.2	79.2	83.0	26.0	77.3	72.6	65.0	61.3	59.7

RUN START TIME 08:07

1	69.9	3.6	71.5	80.7	84.0	23.0	79.3	74.8	70.5	65.4	62.8
2	66.3	4.2	68.4	79.2	79.0	21.0	76.4	72.9	66.3	62.0	59.7
3	63.3	2.6	64.2	70.9	74.0	17.0	70.2	67.3	63.6	60.5	59.0
4	61.7	2.8	62.9	70.1	72.0	16.0	70.7	66.4	61.4	59.3	58.1
5	65.0	5.4	68.9	82.7	81.0	25.0	79.2	73.5	64.0	59.6	57.9
50	65.2	4.8	68.2	80.5	84.0	28.0	77.9	72.7	64.8	60.2	58.3

Table 2

STATISTICAL INDEXES
COMMUNITY NOISE DATA
JEFFRIES POINT, E. BOSTON, MASS.

FEBRUARY 23 & 24 1977

RUN START TIME 21:00 FEBRUARY 23 1977

T	A	S	E	N	M	R	1	10	50	90	99
1	74.4	4.9	76.9	89.4	88.0	25.0	85.3	81.2	75.3	66.9	65.0
2	68.4	5.6	72.5	86.8	85.0	26.0	81.8	78.2	67.8	62.5	60.5
3	64.2	3.6	67.7	76.9	90.0	31.0	79.7	69.0	63.7	61.4	60.2
4	65.0	4.0	68.9	79.1	87.0	28.0	81.1	69.9	64.5	62.2	60.7
5	67.1	3.1	68.6	76.5	82.0	21.0	77.9	71.4	67.3	64.0	62.5
50	67.8	5.6	72.5	86.8	90.0	31.0	83.4	77.2	66.7	62.4	60.7

RUN START TIME 22:00 FEBRUARY 23 1977

T	A	S	E	N	M	R	1	10	50	90	99
1	72.8	3.6	74.4	83.6	85.0	24.0	82.4	77.9	73.2	68.8	66.2
2	70.0	4.6	72.8	84.6	86.0	24.0	82.5	77.3	69.6	65.4	63.3
3	66.0	2.1	66.6	72.0	77.0	16.0	73.3	69.2	66.2	64.1	62.5
4	70.8	4.3	74.2	85.2	90.0	28.0	86.2	75.9	70.9	66.7	64.1
5	67.7	4.3	70.0	81.0	83.0	23.0	78.7	74.2	67.0	63.3	61.7
50	69.5	4.5	72.4	83.9	90.0	30.0	82.6	76.0	69.4	64.6	62.4

RUN START TIME 23:02 FEBRUARY 23 1977

T	A	S	E	N	M	R	1	10	50	90	99
1	66.7	3.0	68.0	75.7	79.0	19.0	76.0	71.6	66.6	64.0	62.1
2	66.7	2.0	67.2	72.3	77.0	17.0	73.1	69.9	66.9	65.0	63.1
3	67.3	1.9	67.8	72.7	75.0	13.0	73.1	70.4	67.6	65.5	64.2
4	67.6	2.9	68.9	76.3	80.0	17.0	76.3	72.8	67.3	65.3	64.1
5	67.0	2.1	67.6	73.0	79.0	17.0	74.0	70.5	67.1	65.1	63.9
50	67.1	2.5	67.9	74.3	80.0	20.0	75.0	70.9	67.1	65.0	63.1

RUN START TIME 00:04 FEBRUARY 24 1977

T	A	S	E	N	M	R	1	10	50	90	99
1	66.2	1.8	66.6	71.2	78.0	17.0	72.8	68.7	66.5	64.6	63.1
2	67.2	2.3	68.1	74.0	81.0	18.0	76.6	70.1	67.3	65.4	64.2
3	65.7	1.8	66.2	70.8	73.0	12.0	71.7	68.8	66.0	64.1	63.0
4	65.6	1.8	66.1	70.7	75.0	13.0	71.6	68.7	65.8	64.2	63.0
5	66.8	3.4	69.1	77.8	85.0	23.0	80.2	71.4	66.3	64.3	63.1
50	66.3	2.4	67.4	73.5	85.0	24.0	76.6	69.4	66.4	64.4	63.1

TABLE 3

SPECIFIC EVENTS
JEFFRIES POINT, E. BOSTON, MASS.
AIRCRAFT DEPARTURES

	JET AIRCRAFT				PROP
	RUNWAY 4	RUNWAY 9	RUNWAY 15	RUNWAY 33	RUNWAY 9
FEBRUARY 23 1977 RUN START TIME 07:00		5 EVENTS		1 EVENT	
	----	76.9	----	75.0	----
FEBRUARY 23 1977 RUN START TIME 08:07	1 EVENT	4 EVENTS			1 EVENT
	70.0	73.5	----	----	72.8
FEBRUARY 23 1977 RUN START TIME 21:00	1 EVENT	5 EVENTS	1 EVENT		1 EVENT
	85.5	82.8	80.5	----	74.0
FEBRUARY 23 1977 RUN START TIME 22:00		1 EVENT	6 EVENTS		1 EVENT
	----	90.0	83.8	----	----
FEBRUARY 23 1977 RUN START TIME 23:02			2 EVENTS		
	----	----	81.3	----	----
FEBRUARY 23 1977 RUN START TIME 00:04			2 EVENTS		
	----	----	81.0	----	----

TABLE 4

SPECIFIC EVENTS
JEFFRIES POINT, E. BOSTON, MASS.
RUNUP AND TAXI OPERATIONS

	JET AIRCRAFT		PROP. AIRCRAFT	
	TAXI	RUNUP	TAXI	RUNUP
FEBRUARY 23 1977 RUN START TIME 07:00	8 EVENTS 71.7 2 EVENTS<65 1 EVENT(M)	1 EVENT 71.8	---- 2 EVENTS(M)	----
FEBRUARY 23 1977 RUN START TIME 08:07	7 EVENTS 75.2 1 EVENT<65 1 EVENT(M)	1 EVENT 70.3	2 EVENTS 74.2	1 EVENT 69.0
FEBRUARY 23 1977 RUN START TIME 21:00	2 EVENTS 80.8	1 EVENT 78.5	3 EVENTS 81.5	2 EVENTS 75.0
FEBRUARY 23 1977 RUN START TIME 22:00	5 EVENTS 77.6 1 EVENT<70	3 EVENTS 75.0	1 EVENT 79.0	----
FEBRUARY 23 1977 RUN START TIME 23:02	3 EVENTS 73.7	1 EVENT 70.5	----	----
FEBRUARY 24 1977 RUN START TIME 00:04	2 EVENTS 75.3 1 EVENT(M)	----	----	----

(M) - LOW LEVELS OBSCURED BY OTHER NOISY EVENTS

APPENDIX J

NOISE MEASUREMENTS

The simplest measure of sound pressure emitted by a given noise source is in terms of decibels (dB). Since very low and high frequencies are not perceived by the human ear, various weightings have been developed to more accurately reflect the noise perceived by the human ear. The most widely used of these is the "A" weighting, measured as dBA. The A weighting gives reduced emphasis to sound frequencies below 1,000 Hertz and to a lesser extent, to those frequencies at the upper end of the frequency spectrum perceivable by the human ear.

The spectular growth in the use of jet aircraft engines, especially in recent years when high frequency, discrete tones became more predominant, brought into serious question the use of dBA as the principal measure of aircraft noise. This resulted in the development of the psycho-acoustically derived measures of sound levels, the objective being the development of a single measure which directly scales subjective response to sounds of widely differing spectral content. This work led to the development of the measure PNL (perceived noise level) and its variant EPNL (effective perceived noise level.) EPNL was developed because it soon became evident that the tonal structure associated with advanced engine designs did not properly relate to the subjective reaction to these sounds in the PNL rating. The problem associated with the duration (as well as the tonal quality) of sounds was also a factor in the development of ENPL which is both time integrated and tone corrected.

The A weighting remains in wide-spread use as a measure of the loudness or noisiness of many types of industrial and traffic noises including aircraft. DBa remains an attractive measure because of the ease of measurement and the high correlation with the subjectively derived psychoacoustic measures. The dBA scale was selected as the scale for the measurements taken on February 23 in order to provide continuity with those measures taken earlier in the year by TSC. Further, since we are interested not only in taxi noise but also APU and tow tractor noise, dBA is the most appropriate sound level measure. The noise indices furnished by TSC does include, however, the measure Noise Pollution Level (NPL). This measure on the TSC summaries is designated by the symbol N. This measure is a noise rating which takes into account the equivalent continuous noise level and the impact of the magnitude of the time variation of the noise level. The intent is to account for community annoyance which is associated with fluctuations in the noise level.

Attenuation of sound is a function of several variables including distance, atmospheric conditions, surface reflection, and acoustic barriers. The distance function is well known--sound intensity will decrease by 6 dB for each doubling of distance. Influencing atmospheric variables include humidity, temperature, and wind direction. Water vapor in the air tends to absorb higher frequencies more readily. It would not be unusual for atmospheric conditions to induce variances of as much as 10 or 20 dB when measuring a constant sound source from several thousand feet. Finally, buildings, hills, etc., serve as barriers to sound; for example, a typical residence can attenuate sound inside the structure by from 15 to 20 dB. It should be noted that at the low thrust levels of typical taxi operations, the predominant high frequency content of the nose attenuates more rapidly than does other typical airport noises such as takeoffs and engine revvups.

GLOSSARY

APU--Auxiliary Power Unit. A self-contained auxiliary engine on an aircraft that provides electricity, heating, air conditioning and hydraulic power when the main engines are not operating.

CO--Carbon Monoxide. A colorless, odorless, extremely toxic pollutant produced from the incomplete combustion of fuel in an internal combustion engine.

dB--Decibel. A unit for expressing the relative intensity of sounds on a scale from zero for the average least perceptible sound to about 130 for the average pain level.

Sound measurements are frequently weighted to approximate a person's hearing sensitivity. Typically, three different weighting networks are used (A, B and C network) in a sound level meter. The A-weighting network is intended to match the response of the ear to sound of low intensity; B-weighting to medium intensity; and C-weighting to high intensity. These decibel measurements are referred to as dBA, dBB, or dBC.

dBA--The A-weighted decibel scale, which has been found to account fairly well for man's perception of sound.

Displaced Threshold--Relocation of the runway threshold for landing aircraft away from the physical beginning of the paved runway area. Typically used in situations where unmovable obstructions exist in the approach area.

Effective Perceived Noise Level (EPNL)--A measure of sound level that 1) includes discrete frequency components of tones associated with aircraft flyovers, and 2) accounts for the (time) duration of the noise signal. Used by the FAA in procedures for certification of aircraft noise (FAR part 36); expressed in units of EPNdB.

FAR Part 36--The FAA Federal Air Regulation that sets noise emission standards for aircraft certification.

GATE Hold--A procedure in use at many airports during periods of air traffic congestion delay, wherein aircraft are held at the boarding gate awaiting departure rather than queueing at the runway.

GPU--Ground Power Unit. A mobile unit of ground equipment usually gasoline powered, that provides electrical power to aircraft. Generally required by aircraft without APU's.

Noise Exposure Forecast (NEF)--A method currently used for making noise exposure forecasts utilizing a perceived noise level scale with additional corrections for the presence of pure tones. Two periods are used to weight the number of flights.

NO_x--The oxides of nitrogen (NO and NO_2) resulting from a parasitic reaction of nitrogen and oxygen combining in the high temperature of jet engine combustors. They are toxic; produce photochemical reactions which can give rise to fog formation, and may be detrimental to other substances in the upper atmosphere.

Perceived Noise Level (PNL)--A quantity expressed in decibels that provides a subjective assessment of the perceived "noisiness" of aircraft noise. The measurement units are termed perceived noise decibels (PNdB).

Preferential Noise Abatement Runways--Runways so designated because their approach or departure paths route aircraft away from noise sensitive areas.

Push-Back--A procedure used whereby a tractor pushes an aircraft away from a terminal where it had been parked, prior to its taxiing under its own power.

Roll-Out--That portion of the landing roll after an aircraft has touched down and decelerated to a controllable speed, but prior to its leaving the runway. It implies that the aircraft is continuing to roll straight ahead on the runway, to turn off at the runway end.

Visual Flight Rules (VFR)--FAA Federal Air Regulations that govern flight conduct in weather conditions that allow pilots to "see and be seen." Weather or flights conducted during those weather conditions.